Digitized by the Internet Archive
in 2023 with funding from
Kahle/Austin Foundation

https://archive.org/details/factorymanagemen0000paul

08

FACTORY MANAGEMENT

BY

PAUL M. ATKINS, M. A.

DOCTEUR DE L'UNIVERSITÉ DE PARIS; SOMETIME INSTRUCTOR IN MANUFACTURING,
SCHOOL OF COMMERCE AND ADMINISTRATION, UNIVERSITY OF CHICAGO; CONSULTING INDUSTRIAL ENGINEER; MEMBER H. N. STRONCK & CO.

THE LIBRARY
UNIVERSITY COLLEGE
CARDIFF

KNOWLEDGE IS BACK OF ALL ACHIEVEMENT
PRENTICE-HALL INC.

LONDON
SIR ISAAC PITMAN & SONS, LTD.
PARKER STREET, KINGSWAY, W.C.2

NEW YORK
PRENTICE-HALL, INC.
1926

Copyright, 1926, by
PRENTICE-HALL, Inc.

All rights reserved

PRINTED IN THE UNITED STATES OF AMERICA

TO

H. B. A.

PREFACE

This book is an attempt to provide the student of manufacturing administration with material which will serve to introduce him to a comprehensive study of this field. It is based on the idea that the control of production is one of the major functions of business administration, a function which in many ways touches and even overlaps that of the technical engineer, on the one hand, while, at the same time, it interlocks with the other business functions, on the other hand.

It has been planned on the supposition that students using it will have already taken a general course in business administration and have some conception of the more important business functions and their interrelationships, and that, in addition, they know something about typical manufacturing processes and equipment.

It has also been assumed that the administration of personnel, one of the most vital problems with which the manufacturing executive has to deal, is sufficiently important to be considered a major function, and, as such, be treated in a separate book. Hence, only incidental reference has been made to this subject in the following chapters.

The author also believes that there is an intimate connection between production control and factory cost accounting, and, hence, a final chapter dealing with this relationship has been included as a link between this book and his "Textbook of Industrial Cost Accounting."

Thanks are due to the editors of several magazines, and to authors whose articles have appeared therein, for permission to reproduce certain illustrations, and also to the officers of certain companies who have supplied illustrative material.

Specific acknowledgment is made in each case. The author wishes also to express his obligations to the students of the various classes on whom this material has been tried out and who have aided its development by their questions and comments. He is indebted to Helen B. Rohrke (Mrs. Lloyd E. Rohrke) for assistance in gathering material for this volume. He wishes especially to express his gratitude to his wife whose aid and counsel during the composition of this book have been constant and unfailing.

PAUL M. ATKINS

CHICAGO

CONTENTS

CHAPTER PAGE

I—THE CONTENT OF MANUFACTURING ADMINISTRATION 1

Meaning of factory administration; Groups of similar business problems; The task of the factory executive; Problems common to several functions of a business—the finished product, the functionalization of a business; Selection of equipment; Power production and transmission; Internal transportation equipment; Plant layout; Building construction; Plant maintenance and repair; Material; The workers; Manufacturing standards; Current control of production; The scientific approach to these problems; General rules, laws or principles; Art of management; Factory administration and pure and applied science; Learning the art of management; Necessary moral qualities for industrial leadership.

II—THE RELATION OF THE FINISHED PRODUCT TO FACTORY PROBLEMS 12

Design of the product; Savings resulting from the elimination of parts; Standardization of parts; Analysis of the material composing the product; Ease of manufacture; Selection of equipment; Selection of labor; Internal transportation; Type of building construction; Manufacturing standards; Task of designing the product.

III—FUNCTIONS AND THEIR CLASSIFICATION 22

Three main groups of functions; Detailed analysis of the functions; Typical symbolized classification of functions; Departments, the functional units of organization; Functions involved in the design and development of the product; Relation of the design functions to other functions; Financial functions; Industrial relations Departments; General administration functions; Distribution or marketing functions; Auxiliary manufacturing functions; Purchasing department; Factory cost department; Manufacturing standards department; Direct manufacturing departments.

CHAPTER PAGE

IV—THE INTERNAL ORGANIZATION OF A MANUFACTURING CONCERN 34

Organization on the basis of functions; Cost of pseudo-organization; Three outstanding types of organization—(1) Line, (2) Line and staff, (3) Taylor; Committees and their place in the organization; Relations other than those of authority and responsibility; Organization Manual; Organization charts; Place of individuals in the organization.

V—THE SELECTION OF EQUIPMENT 48

Analysis of equipment requirements; Needs of the jobbing factory; Importance of idle equipment; Development of the product; Development of manufacturing process; Character of the product; Available labor supply; Rate of production; Integration of equipment; Analysis of available equipment; Analysis of cost factors; Plant register; Basis for action on the part of the executive.

VI—POWER PRODUCTION AND TRANSMISSION 63

Nature of the power problem; Ascertaining power requirements; Measurement of probable power consumption; Fluctuations in power consumption; Power consumption by auxiliary equipment; Power consumed for artificial lighting; Consumption of power for heating; Obtaining power from a central power station; Hydro-electric power; Steam power; Boiler and its accessories; Water purification; Super-heaters; Boiler furnace; Automatic stokers; Combustion; Choice of fuel; Steam engines; Reciprocating steam engine; Steam turbine; Reciprocating engine and steam turbine compared; Internal combustion engine; Power transmission; Rope drive; Belt; Shafts; Electrical transmission; Other forms of power transmission.

VII—INTERNAL TRANSPORTATION EQUIPMENT 83

Approach to the internal transportation equipment problem; Material to be moved; Nature of industry; Available power; Building construction; Fire hazards; Vertical movement of material; Horizontal movement of material; Distance material is to be moved; Hand vs. power transportation equipment; Material handling equipment.

VIII—PLANT LAYOUT 104

Value of ideal plant layout; Factors controlling the layout; Analysis of manufacturing processes; Importance of satisfactory layout; Plant layout in a continuous process type of factory; Plant layout in the jobbing type of industry; Interrelationship of departments; Future expansion; Graphic methods of recording a plant layout.

CHAPTER PAGE

IX—THE CONSTRUCTION OF A FACTORY BUILDING . . 116

Building, a master tool; Effect of the product on building construction; Effect of equipment on the design of the building; Limitations placed on a building by its location; Height of a building; Fire hazards; Building foundations; Type of building construction; Frame construction; Slow-moving or mill type of construction; Automatic sprinklers; Steel frame type of construction; Reinforced concrete construction; Walls of the building; Roofs of factory buildings.

X—THE MAINTENANCE AND UPKEEP OF THE PLANT . 132

Reasons for the importance of maintenance; Adequate upkeep means lowered depreciation; Satisfactory maintenance reduces capital investment; Reduces accidents; Losses due to idle equipment; Classification of maintenance and upkeep; Accidental repairs should be reduced to a minimum; Planning of maintenance work; Scheduling of upkeep; Control of regular but infrequent maintenance.

XI—MATERIALS—THEIR SPECIFICATION AND CLASSIFICATION 143

Characteristics of materials; Selection of materials; Specification of materials; Specifications from the economic viewpoint; Recording the specifications; Symbolization of materials.

XII—THE SELECTION OF THE WORKERS 150

Workers as a part of our social organization; Basis for the selection of workers; Elements of employee specifications; Turret lathe hand; Storekeeper; Production manager; Use of employee specifications in the control of production; Benefits of employee specifications to the workers; Selection of the workers.

XIII—MANUFACTURING STANDARDS 158

Standards, a means of "transfer of thought, skill and intelligence"; Development of standards; Basis of manufacturing standards; Standards for material; Equipment standards; Setting of operation standards; Function of time and motion studies; Relation of fatigue to standards; Qualifications for a time study engineer; Making standards permanent.

XIV—ROUTING THE WORK THROUGH THE FACTORY . . 166

Routing, an analysis of the direct manufacturing function; Routing both a technical and economic problem; Effect of quantity to be produced at one time; Provision for alternative equipment; Reduction of material handling; Recording the routing of orders.

CHAPTER PAGE

XV—MAKING TIME AND MOTION STUDIES 175

Standards affected by time and motion study; Worker's relation to time and motion studies; Preliminaries to time and motion studies; Standards for material; Standards for equipment; Type of men needed for making time and motion studies; Requirements for a time study engineer; Location for making a time study; Methods of making time and motion studies; Analysis of operation into suboperations; Importance of determining correct suboperations; Time study sheet; Position of the observer; Recording of continuous times; Setting operation standards; Constructive time studies; Calculating the standard time; Allowances.

XVI—FATIGUE AND ITS RELATION TO MANUFACTURING STANDARDS 191

Nature of fatigue; Common interest of worker and employer in fatigue; Fatigue reduces output; Fatigue reduces quality of product; Way in which results of fatigue are experienced; Classes of shop operations from standpoint of fatigue; Elements of work which affect fatigue; Relation of the worker to the fatigue problem; Measurement of fatigue; Reduction of fatigue in the factory; Control of the worker over fatigue reduction; Fatigue allowances and rest periods.

XVII—MAKING STANDARDS PERMANENT 201

Operation and routine work standards; Instruction cards; Preparation of instruction cards and standard practice instructions; Classes of standard practice instructions; Continuous instruction of employees; Instruction by foremen and subforemen; General training of employees; Course of lectures; Regular courses at night school or factory; Talks by department executives; Factory hands informed of management policies; Relation of incentives to permanency of standards.

XVIII—CLASSIFICATION AND SYMBOLIZATION 219

Classification; Symbolization; Relationship of symbols to classification; Significance of classification and symbolization in factory administration; Methods of symbolization; Classification basis; Control of classification; Practical approach to the classification problem; Permanent value of recorded standards.

XIX—THE DESIGN OF PRINTED FORMS 230

Importance of printed forms; Reasons for utility of printed forms; Arrangement of spaces on forms; Defects in the design of forms; Reasons for trouble with forms; Control of the design of factory forms; Size and shape of forms; Arrangement of filing data; Preparation of groups of forms

CHAPTER PAGE

by duplicating devices; Use of a single form by several departments; Typewriter spacing between lines; Typography of printed forms.

XX—A MASTER SCHEDULE 261

Forecasting the future; Interdependence of production and other functions; Master schedule; Basic schedules of a manufacturing concern; Productive capacity of a factory; Meaning of "productive capacity"; Sales schedule; Labor schedule; Material schedule; Financial schedule; Preparation of the master schedule.

XXI—PLANNING AND SCHEDULING PRODUCTION 270

Planning; Scheduling; Dispatching; Relationship of planning, scheduling, and dispatching; Planning and scheduling of specifications; Control of manufacturing standards; Routing orders through the factory; Planning and scheduling tool design and production; Operation standards; Planning and scheduling manufacturing orders; Relation of the master schedule to production scheduling; Scheduling equipment; scheduling materials; Control of the workers; Control of the orders.

XXII—MATERIAL CONTROL 281

Classification of materials from the control standpoint; factors in material control; Scheduling of material; Material lists; Ordering of material; Maximum and minimum quantities; Purchase requisition; Purchase control form; Internal material control forms; Material control in the continuous process type of factory.

XXIII—BUYING MATERIALS 295

Requisites for satisfactory purchasing; Need for accurate specifications; Market knowledge essential to sound buying; Effect of the business cycle on purchasing; Purchase schedule; Purchasing procedure; Obtaining bids for material; Purchase order; Following up purchase orders; Control of purchases in transit; Passing the invoice; Goods which do not pass inspection; Purchase control forms; Standards of procedure.

XXIV—RECEIVING, STORING, AND ISSUING MATERIAL . . 306

Location of the receiving department; Inspection of incoming shipments; disposition of the receiving slips; Location of the storeroom; Storeroom equipment; Layout of the storeroom; Double bins and hopper bins; Issue of materials; Material issue forms; Inventories.

CHAPTER PAGE

XXV—DISPATCHING WORK THROUGH THE FACTORY . . 317

Dispatching; Dispatching—a coördination in respect to time and place; Dispatching in a continuous process type of factory; Dispatching in the jobbing type of industry; Dispatching of equipment; Dispatching of material; Control of first inspection; Dispatching of final inspection; Dispatching the movement of materials; Following up dispatched orders; Relation of dispatch clerks to factory foremen; Location of the dispatcher; Determining the time dispatch orders; Dispatch board; Controlling the order of work; Significance of the dispatch board; Schedule card; Unit of scheduling and dispatching.

XXVI—THE PRODUCTION, STORAGE, AND ISSUE OF TOOLS . 330

Classification of tools; Design of tools; Relation of tool production to merchandise production; Control of tool design; Storage of tools; Maintenance of tools; Tool cribs, Tool storage equipment; Layout of a tool crib; Duties of tool crib attendant; Grinding of tools; Issue of tools; Single check system; Double check system.

XXVII—INSPECTING MATERIALS AND SALVAGING DAMAGED GOODS 340

Significance of inspection; Basis of quality inspection; Extent and methods of inspection; Kinds of material to be inspected; Inspection of goods in process; Quantity inspection; Staff of inspectors; Place of inspection department in the organization; Disposal of rejected materials; Treatment of damaged stores; Salvage of spoiled worked material; Reinspection of unsatisfactory goods; Control of salvage operations; Organization of the salvage work.

XXVIII—STOCKING AND SHIPPING THE FINISHED PRODUCT . 350

Stocking the finished product; Layout and equipment of the stock room; Measurement of goods for shipment; Packaging of goods for shipment; Improvement of containers; Packing of large-sized units; Preparation of shipments for export; Organization of the finished stock and shipping department.

XXIX—RECORDS AND THEIR VISUALIZATION 357

Basis for the selection of needed records; Idle time reports; Spoilage reports; Idle man hours; "Exception" rule; Availability of reports; Organization chart; Visualized specifications of materials; Equipment records and plant layout; Operation standards; Control of current production; "Telltale" board.

CHAPTER PAGE

XXX—THE RELATION OF THE PLANNING AND COST DEPARTMENTS 367

Proper place of cost accounting in business control; Scope of industrial cost accounting; Relation of production control records to cost accounting; Pricing of material issues; Preparation of time tickets; Other records furnished by the Planning Department; Auditing of vouchers prepared by the Planning Department; Auditing methods; Tact necessary in auditing; Cost reports to aid production control; Cost of idleness; Comparison of actual costs with standard costs; Product and operation costs.

FACTORY MANAGEMENT

Chapter I

THE CONTENT OF MANUFACTURING ADMINISTRATION

Purposes of this chapter.—

1. To investigate what is meant by factory administration and outline its scope.
2. To consider its relation to the administration of the other phases of a business.
3. To survey the content of factory administration.
4. To consider the approach to be made to the study of the problems involved.
5. To survey the relation of factory administration to science.
6. To outline what is involved in the art of administration and the qualities necessary to an executive.

Factory administration, meaning of.—Any business enterprise is made up fundamentally of certain groups of activities and the means—material and human—for carrying them on. In a manufacturing concern the basic functions are those involved in designing, fabricating, marketing, and financing the product. These functions are bound together and their coördination facilitated by such activities as those involved in keeping of records, the handling of the personnel, and the general administration of the business. Each of these functions deserves individual attention, and their proper coördination demands the best abilities of business executives. In the following chapters the attempt is made to deal only with the activities which are necessary to the administration of the fabrication of the finished product in a modern manufacturing business.

Groups of similar business problems.—Until recent years business men have felt that their own particular business was different, and that there was little in common between the problems which they had to face and those encountered by their associates in other concerns. There is a very considerable amount of truth in this feeling which cannot be ignored nor overlooked. If this were wholly true, however, it would seriously hinder, if not altogether prevent, any consideration of types of problems which are common to various industries. It is becoming more generally recognized that, no matter how much the aspect of the problems of different concerns vary, within certain classes of companies there are fundamental questions which may be answered in general terms and which will serve as a basis for the solution of a particular problem.

No business, for example, is able to grow to any size without having some kind of an organization, sometimes unrecognized, and often very seriously neglected. The problem of the proper organization of the company exists for all, and unless it is adequately solved it will demand constant attention.

No manufacturing enterprise can possibly turn out salable merchandise without the use of a certain amount of equipment, the consumption of some material, the services of at least a few workers, and the utilization of definite methods of operation and control. Here, then, are certain basic questions for which every company must find some kind of an answer—inadequate and inefficient though it may be—if it wishes to remain in business.

The task of the factory executive.—The task which confronts the factory executive is to take these various elements and such others as may be necessary and so manipulate and control them as to be able to deliver the product which is wanted, when it is wanted, at a minimum cost of production. Unless he accomplishes this his work cannot be said to have met full success. His problem, therefore, is largely one of control, administration, management—the establishment of policies and the putting of those policies into effect.

Problems Common to Several Functions of a Business.—The Finished Product.

Obviously, it appears that before taking up a discussion of the questions which are primarily within the field of factory administration, it is necessary to consider certain factors which are of vital importance to all the principal functions of a manufacturing business. One of the most conspicuous of these elements is the finished product, for it represents the underlying reason for the very existence of the business in question. It is, or should be, one of the fundamental factors in the development of the marketing and financial policies of the company. It influences the location of the plant, and there are few manufacturing problems on which it does not have a bearing, directly or indirectly. The kind and quality of the product determine, in large measure, the material to be utilized and operations to be performed to produce it, and the latter, in turn, dictate to a certain extent the kind of machinery to be employed, the internal transportation equipment to be used, the type of building construction to be selected, the class of workers to be hired. The extent to which manufacturing standards of various kinds are to be developed and the methods of production control depend in part upon the operations and equipment. It is necessary and appropriate, therefore, to consider briefly at the very start the finished product and its probable influence on problems of manufacture.

The functionalization and organization of a business.—It is also essential that there should be a systematic analysis of the activities of the business into carefully defined functions and the coördination of these functions in the form of an organization. It is difficult to appreciate the relationship of the manufacturing activities to each other and to the other functions of the business unless this study is made. In a manufacturing concern most of the activities, of course, come under the general head of manufacturing functions, and hence the discussion of this question is especially necessary when dealing with factory administration. It will also be found that there are a number of activities which are likely to be claimed by more than one executive of the company, and it is necessary, therefore, to weigh the pros and cons of the issues so raised, for the decision as to the location of any activity in the organization of the concern should be based, not on personal bias but on a careful analysis of where it should be placed in order to render the best service to the business as a whole.

The selection of equipment.—With an outline of these important factors in mind it is time to proceed to an investigation of the problems which are fundamentally questions of factory administration. One of the first of these, chronologically, is the selection of equipment. If the tools and machines are relatively simple and inexpensive, this problem is not a very serious one, for if a mistake is made it will not be costly to rectify it. If, on the other hand, there is considerable investment in equipment it is very important that errors be avoided so far as possible, for if an inappropriate machine for the task in hand is selected the result of excessive costs of acquisition and losses in operation will be felt over an extended period of time. Here is a question which occurs not only when a company is just starting in business, but which is constantly reappearing as the necessity for new equipment is felt to replace that which is discarded or to provide for additional output.

Power production and transmission.—While it is true that a large number of companies, especially small ones, purchase their power from a central power station, it is equally true that for many concerns the production of power with which to operate their machinery is a matter of fundamental importance. The supply of power has a marked influence on questions of factory administration, especially in two ways. The lack of it for any reason whatever hinders, if it does not altogether stop, production, and anything which reduces output results in hidden but nevertheless very real losses. Losses of power in transmission or through faulty and improperly designed power-producing machinery is one of the most difficult kinds of losses to locate, but one of the most serious if allowed to go on unchecked. From the point of view both of control of production and cost of production, the factory manager is interested in the power problem.

Internal transportation equipment.—There is no manufacturing business in which the question of the kind of internal transportation equipment does not demand some consideration. Even in jewelry establishments, when the weight and bulk of the product to be moved is reduced, in most cases, to a minimum for the value involved, there is still the problem of adequate protection against loss or damage to the materials in transit. In some cases, take the Ford plant, for example, the methods of internal transportation have been a major factor in the development of the manufacturing processes. In the small factory, especially of the jobbing or the intermittent type, this question, which may seem small in itself, is often large in proportion to other problems.

Plant layout.—Once the equipment of all kinds has been selected, the task of properly laying out the plant must be solved. If the buildings are yet to be constructed, an ideal layout may be approximated quite closely in many instances. If the buildings are already erected, then the ideal plan serves as a model to be approached as nearly as possible within the limits imposed by actual conditions. Fundamentally, of course, the plant layout should be based on the routing of the work through the factory, and, in a continuous process type of industry, this basis ordinarily can be used. In the jobbing type, however, the problem is much more complex and demands very careful analysis of many factors.

Building construction.—Every factory must be housed, and the kind of housing or construction used affects very materially the administration and operation of the factory. A building well designed from the point of view of the processes to be carried on therein is one of the greatest aids to the economical operation of the factory. The factory structure should be looked upon as a master tool of the business and not simply as a protection for its contents against the weather. For this reason, the layout of the equipment should be prepared, if possible, before the building is designed.

Plant maintenance and repair.—Once in operation the building and the machinery of all kinds must be kept in satisfactory operating condition. Unless this is done, the best-laid plans and schedules for the operation of the factory are sure to be upset with consequent losses of time and increased costs. To a large extent, most factories can have their maintenance and repairs planned in advance and the unexpected breakdowns reduced to a minimum. Such, at least, should be the goal of every factory manager, and it is much more nearly realized than is commonly appreciated.

Material.—Material involves two major problems: one is its selection, definition or specification, and classification; the other, its actual purchase. The first must be solved in some measure before the second can be attacked, for, without a fairly definite knowledge of the material wanted, it is extremely difficult, if not impossible, to purchase it. In dealing with the first of these problems, a thorough technical knowledge of the product is necessary, such training as is given in schools of engineering, etc., being the basis for additional experience in handling practical questions which arise. To be in a position to deal with such problems to the best advantage, a knowledge of physics, chemistry, the mechanics of materials, and often metallurgy and other specialized technical subjects is desirable. For coping with the other problem, an understanding of marketing institutions and methods is essential and a thorough familiarity with the needs of the business and the methods of production control is necessary.

The workers.—The questions which arise in connection with the workers are extremely varied and numerous. In recent years, increasing emphasis has been laid on the social significance of the problem involved and the relationship of the company to the worker as a human being has been stressed. The attention given this phase of the matter is right and proper, and the executive who overlooks or neglects it is sure to suffer in consequence. The question is one of vital importance. On the other hand, it must not be forgotten that the workers are one of the means of production and that, unless they are efficient in this respect, the company is sure to feel the ill effects of inefficiency. It is often a difficult task to reconcile the conflicting interests of the workers and the company, but it is a task which cannot be avoided.

Manufacturing standards.—When all these problems have been discussed, there still remain those which are concerned with the establishment of manufacturing standards. The most important standard, from the point of view of the factory executive, is the group made up of operation standards which find their tangible expression in instruction card and standard practice instruction. They are the basis for the current control of production. Before such standards can be set up, however, it is necessary to establish certain others, such as standards for product, materials, equipment, and workers. Unless standards for these factors are established and maintained, it is impossible either to set up or to use proper operation standards to control production.

The development of the various manufacturing standards is essentially the providing of tools which are needed in the control of current production and a preparation for the easy and smooth functioning of the work which follows. Not only must the standards be set but they must be maintained.

Current control of production.—While the manufacturing standards are the basis for the control of production, they are not by any means the whole of it. Another fundamental factor in that control is a knowledge of the probable quantity of production which will be required. To obtain an estimate of this kind it is necessary to forecast the future not only in regard to factory operations, but also especially in respect to marketing and financial prospects. It is essential, therefore, to build a master schedule from the data provided by subordinate schedules—a schedule which will serve in turn to control the detailed schedules, one of which is for production.

Once the schedules are established, they must be put into effect, and the mechanism for the purchase, receipt, storage, and issue of materials, the storage and issue of tools, the dispatching of work through the factory, the inspection of the goods in process, the elimination and proper treatment of unsatisfactory units, and the recording of all the various steps as a basis for measuring results against plans must be set in motion. All these activities are involved in the day-by-day operation of the factory and they must be properly coördinated if successful results are to be obtained.

The scientific approach to these problems.—In dealing with these problems the same general approach should be made, no matter what the nature of the industry involved may be. The first task is to find out what the need is, and the next, to discover some means of meeting that need from among those which already are available or to develop an adequate solution if one does not already exist. This general statement is easily enough made; but in its application to any particular case, all the skill, training, experience, and good judgment of the most capable executive are often taxed to the limit.

In order to obtain the highest degree of control over any problem involved, whether large or small, substantially the same process should be performed each time. The problem should be analyzed, the results of the analysis classified, measured, and evaluated, a selection of the necessary elements made, new elements developed as may be needed, and then the selected elements synthesized. This is essentially the method of pure science applied to business problems, and, while many of the problems are much more complex than the majority of those met with in pure science, imponderable variables, in the shape of the human factor which enters into so many business questions, tend to render the results less accurate than they are in pure science, it is only by following this scientific method that the science of business has been built up to its relatively high degree of perfection as compared with a few years ago. There is no reason to believe, however, that anything more than a start in this respect has as yet been made. It was this method which Mr. F. W. Taylor endeavored to follow and which gives a basis for calling the work which he did "scientific management." He analyzed and classified indefatigably, and his development of time and motion study was simply the result of his effort to provide himself with a measuring device for evaluating certain shop operations. Others since his day have developed this device far beyond the relatively crude form in which he used it, but time and motion study in whatever shape they may have are measuring devices as well as the sign and symbol of the application of the scientific method to the problems of industrial administration.

General rules, law, or principles.—When this scientific method has been applied to a sufficiently large number of comparable cases, certain general rules or laws may be deduced which, when adequately tested under a wide variety of conditions, may be called "principles." The science of business administration has hardly been carried far enough yet to make it possible to state that very many principles have been developed; but it is possible to say that certain general rules have become established, some of which are noted in the course of the following chapters.

The art of management.—In the application of these general rules or laws to particular cases is found the "art" of management as distinguished from the "science" of management by which the rules are being established. Most of the time of business executives is given to the art rather than to the science of management; to getting things done and making decisions in particular cases rather than to analyzing, measuring, and deducing general laws from their observations. This is as it should be, and accords with what is found in the scientific world, where far more men are engaged in applying the principles of pure science to particular engineering problems than are occupied in developing those principles. Of course, there is no hard and fast line between art and science and many men are occupied with both.

Factory administration and pure and applied science.—In many ways the connection between the particular phase of business administration which is discussed in this book and pure science, especially as represented by physics and chemistry, is much closer than in some of the other phases. Two of the principal factors which enter into the administration of a factory—materials and equipment—involve very many technical problems. To be a good factory executive it is essential that a man be familiar with the elements of general engineering. Without this training or experience he is seriously handicapped in his efforts to deal with many of the practical problems with which he is confronted, and also in working with the men under his supervision who are primarily technical men handling engineering problems.

Learning the art of management.—While science will aid any man greatly in solving the problems of management, the art of management is something which can be acquired only by constant practice in dealing with practical problems. The man who is endeavoring to acquire a knowledge of management should possess: (1) certain physical qualities, such as strength and stamina, which will enable him to endure long and arduous toil; (2) a well trained intellect which has acquired through careful instruction a comprehension of the underlying rules and laws of management, their interrelationships, and the ways in which they have been built up; (3) experience—that personal contact with events and problems which alone can give a man confidence in dealing with similar contacts later. It should be remembered in this connection that experience does not lie so much in simply observing or taking part in a series of activities as it does in appropriating and making a part of one's intellectual and moral equipment the essentials of the events observed or participated in and the problems worked upon. One man may gain a great deal of experience from that which is a meaningless haze to another. Experience depends, then, on ability to pick out and assimilate essentials as well as on a will to do so.

Necessary moral qualities for industrial leadership.—Finally, the ability to learn the art of management and to become a capable and resourceful executive depends upon the possession of certain moral qualities—honesty, patience, persistence, a sense of justice and proportion, tact, fidelity, consideration for the welfare of others, personal integrity, and all those other elements which serve to make up what is known as good character. While the control of material and other inanimate objects comes within the scope of the exercise of the art of management, it must not be forgotten that this control is largely exerted through other individuals, and that, in addition, one of the most important factors to be controlled is composed of the subordinates which a man has under him. More and more it is being recognized both here and abroad that a man's character is his most important asset, and that on it depends very largely his own success and that of the work which is confided to him. The man who has the courage to stand firm when others quit, who by his daily conduct proves himself to be worthy of the confidence of others is almost certain to find himself a leader, because he has the qualities of which leaders are made.

The importance of these qualities in men who are to hold positions of responsibility is being more and more recognized every day. They are especially necessary to those who expect to become industrial executives, for they are likely to affect the lives and fortunes of many more individuals than are executives in charge of other functions who have fewer workers under them. In recent years men like John Hays Hammond and Professor Joseph W. Roe in this country and Monsieur Henri Fayol in France have emphasized these points in connection with the training of young men for the business world, and that their opinions are supported by the vast majority of the engineers of this country was borne out by a nation-wide investigation.

While what follows is devoted very largely to the non-human phases of factory management—as the administration of the personnel is a sufficiently large and important question to need a separate book entirely devoted to its consideration—the student should constantly bear in mind the underlying and basic character of the ideas expressed in these last few paragraphs.

References for Additional Reading.

Church, A. H., "Science and Practice of Management," Chapter XII.
Durell, F., "Fundamental Sources of Efficiency" (entire book).
Gantt, A. L., "Organizing for Work" (entire book).
Hammond, J. H., "The Engineer," Chapters IV-VI.
Kimball, D. S., "Plant Management," Chapters II, III, XXI.

CHAPTER II

THE RELATION OF THE FINISHED PRODUCT TO FACTORY PROBLEMS

Purpose of this chapter.—To consider some of the ways in which a knowledge of the finished product affects the solution of factory problems.

A study of the finished product is essential to the solution of very many problems of a manufacturing enterprise. The kind of product determines to a certain extent the location of the plant. Most marketing problems depend for their solution on an intimate acquaintance with the product and its relation to present and probable future demand for it, its adaptability to meeting that demand, its serviceability in use, its freedom from need of repairs, its attractive appearance, etc. Without an acquaintance with these and other phases of the product it is quite impossible to plan a definite campaign for the distribution of the merchandise.

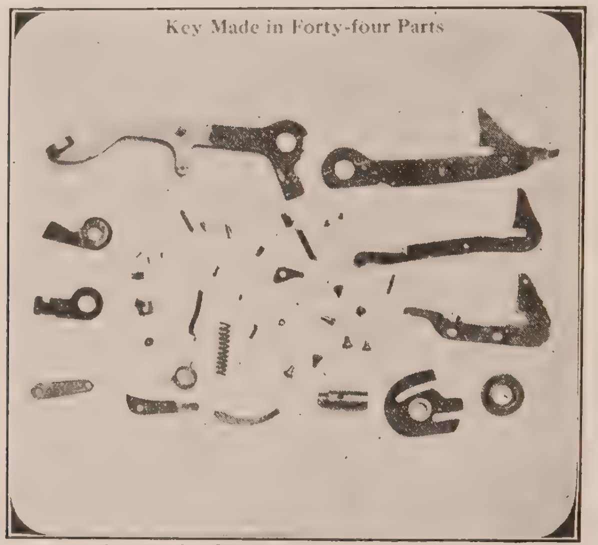
It is especially in connection with the solution of manufacturing problems that a knowledge of the finished product is of most service. There are hardly any factory problems which are not directly or indirectly affected by the nature of the article which is being fabricated. Hence, it is essential for a factory executive to be thoroughly familiar with the goods which he is producing.

The design of the product.—As the product is analyzed one of the most obvious factors which demand attention is its design. To the casual observer, who is much more likely to be a consumer in some form or other of the article under consideration than a producer thereof, the principal points which will probably be thought of first are—appearance, suitability to his personal needs, strength and durability, ease of repair, etc. If the design of the article shows due consideration to these points, he is satisfied. An automobile offers a good illustration. The design should be such as to make the car as attractive as possible, and if a comparison is made between cars of to-day of the medium or low priced variety with the best of the automobiles turned out fifteen or even ten years ago the contrast is most striking. At the present time also much care has been given to the design of the car to meet special needs, and hence pleasure vehicles of many varieties—open and closed—are offered to the public, and, in addition, buses and trucks of all kinds to meet industrial needs have been manufactured. Much progress has also been made in the direction of increased strength, durability, and ease of repair of motor cars of all sorts.

The factory man, however, considers design from a distinctly different angle, for to him the principal points are ease and low cost of manufacture—both of which have a common basis. One of the first ends which he seeks in analyzing the product is to reduce the number of parts of which the automobile is constructed. Everyone is familiar with the advertisements which state that this or that make of automobile have so many parts less than any other car in its class. While the primary object of the advertisement is to emphasize the simplicity of the car from the point of view of the consumer, it carries with it the information that, in certain respects at least, ease of manufacture has been promoted.

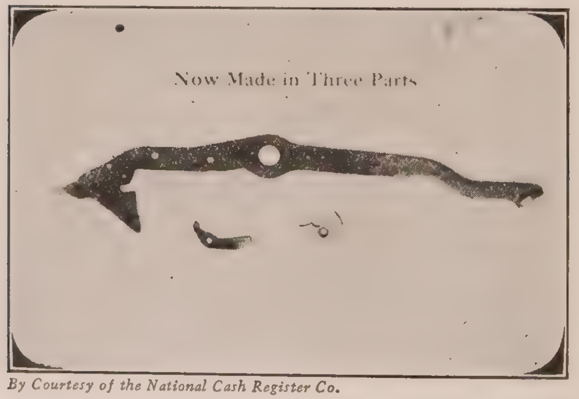
The National Cash Register key.—Another excellent example of this kind of thing is given in Figure 1 (p. 14), which shows the results of the careful study made at the National Cash Register Company of a problem of this kind. Before the analysis of the product was made, forty-four parts were required to make the key assembly in the illustration. After the problem had been studied it was found possible to reduce the number of parts to three, a net saving of forty-one parts.

Savings resulting from the elimination of parts.—The savings from such a change in design come in several different ways. In the first place, there is the lessened material requirement, for less steel is actually consumed in making the parts. This means that smaller quantities of steel must be purchased and hence a smaller inventory is needed. Not so much space is required in the storeroom to store the raw material till it is required, and as a result storage costs are reduced. After the parts are made the effect on the storage problem is felt to a much greater extent, for there are only three parts to be stored instead of forty-four. Not only is less space required, but very much less labor on the part of the storekeeper and his assistants is necessary for handling the parts. The number of store records is also greatly reduced, and with the smaller number the chances for errors are minimized to a considerable



By Courtesy of the National Cash Register Co.

Fig. 1A.—National Cash Register Key before Redesign.



By Courtesy of the National Cash Register Co.

Fig. 1B.—National Cash Register Key after Redesign.

extent. As the number of parts is cut many of the operations needed to make them are also eliminated, and in this way the cost of production in so far as direct labor and earned burden are concerned is reduced. More machine hours are made available for other tasks, and thus the capacity of the factory is virtually increased. Some of the machines which were formerly required are no longer necessary at all, and, if not needed for other purposes, can be eliminated altogether. The whole problem of planning, scheduling, and dispatching the operations for making the subassembly is greatly simplified, and the number of records involved and labor entailed in the Planning Department are cut appreciably. All this means greatly increased ease in control and in manufacture in the shops and greatly decreased costs.

The standardization of parts.—The analysis of the design of the product with the object of cutting down the number of parts of which it is composed is only one way in which it should be studied. Another gain to be sought is the standardization of the parts so as to eliminate as many special parts, materials, or subassemblies as possible.

There are really two ways in which materials and products may be said to be standardized. In the first place, there are standards which have been generally adopted, like those for screws, nuts, bolts, electric light sockets, grades of steel and iron, etc. These may be called "commercial" standards and their number and variety are being rapidly augmented. On the other hand, are standards which are standards only from the point of view of a particular company; these are much more numerous than the others. There is a tendency, of course, for the latter to become commercial standards, either by common agreement among the manufacturers producing the goods or because of the dominating position in an industry attained by some one concern.

Either class of standardization helps in the manufacture of goods. As soon as any part or article becomes commercially standardized, certain companies are almost sure to specialize in the production of those goods and turn them out in large quantities. Usually competition and other causes make them sell their articles at a moderate price, lower, in fact, than the cost at which any independent company can produce except in very large quantities. The use of commercially standardized parts results in several economies for the consuming company. Lower first cost is one of these and the most obvious in the light of the facts just stated. If it is possible to purchase standard parts in the open market, it becomes possible to operate efficiently on much smaller inventories than would otherwise be safe, and this also means reduced costs. The whole control of production is simplified, for, instead of being obliged to make the parts, it becomes possible to buy them, and hence a whole series of factory operations are eliminated and with them the system of records necessary for their control.

There is no excuse for using special parts where standard ones will do just as well, except in the case of luxury goods, where individuality is the key to the business policy. To use standard instead of special parts may mean that it will be necessary to depart in some aspect from the ideal design. A larger sized screw than the real needs of the product demand may have to be used, for example; but that is a small matter compared with all the cost and bother of making special screws. The fewer the number of parts needed in the course of a year, the greater is the resulting cost, if the parts are special, and, hence, the jobbing type of industry in particular should make every effort to utilize standard parts. If a good many thousand screws are consumed in a week in turning out the merchandise, it may be possible to keep an automatic screw machine busy, and hence it does not make so much difference if they are special; but if only a few hundred are required the quantity may be only sufficient to warrant the use of an engine lathe.

The arguments in favor of employing parts which are standardized from the point of view of the individual concern are quite similar to those which apply in the case of commercially standardized materials. There is one additional factor which needs to be mentioned in this connection, however. If the parts are standardized, they can usually be produced in larger lots than the special materials, and this results in economy of manufacture. It is also much simpler to control the production of goods made up in large quantities than to direct the manufacture of small lots. A certain company producing Corliss engines offers a good illustration of the benefits to be gained from this kind of standardization. The engines were so designed that a variety of standard parts could be assembled in different ways to make different kinds of engines as needed.

If an order came in for an engine of a certain horse power to use steam at high pressure, a particular bed and high pressure cylinders would be selected from among the standard components. If the same horse power were required, but steam at low pressure were to be used to develop it, the same bed would be chosen but different cylinders. In this way the production of steam engines was changed by this concern from a special order proposition to an almost straight manufacturing problem, except for the final assembly, and in this way costs were decreased and ease of control augmented.

The use of standard parts whenever possible reduces both costs and factory problems to such an extent that there is no excuse for not using them when there is any opportunity for doing so. The only way in which this problem can be solved is by basing the solution on a careful analysis of the product and all of its components. It is a problem which can be handled only by one who is familiar not alone with technical questions but with many of the phases of market administration as well. The interests of these two functions of the business are likely to clash at this point, and tact, as well as knowledge, is necessary to reconcile them.

Analysis of materials composing the product.—The kind and quality of materials to be used is another question which is involved in the design of the product. Any decision in this matter is certain to affect the manufacturing operations in one way or another. The problem may easily arise as to what grade of steel it is desirable to use in the production of a particular article. A concern making a metal box, the cover of which was drawn in a punch press to a certain shape, was obliged to experiment for a long time in order to determine the right kind of steel for this purpose. If it were not sufficiently hard, it would not withstand the rough usage to which it was likely to be subjected. If it were not sufficiently soft, it would require two, and, in some cases, even three, drawings in the punch press to form it into the shape desired without cracking it in the process. Two drawings in place of one would about double the cost for this particular operation. To a large extent the solution of the problem hinged on the selection of the right kind of material. The whole course of manufacture of this product, its working through the factory, the operations to be performed upon it, the tools to be used in doing the operations, all depend in part on its design in this respect. The substitution of aluminum for steel in the production of many articles from saucepans to automobiles has necessitated many changes in the operations to be performed in producing these goods. The starting point for dealing with the manufacturing processes involved is the analysis of the finished product from the point of view of the kind or grade of material used.

Ease of manufacture.—The design of the product needs to be studied from the point of view of ease of its manufacture. Often some relatively slight change in the design will result in a greatly decreased amount of time and labor required in its production. The case of fan bracket on a certain automobile offers a good illustration. It was so designed that it required a one-quarter-inch hole to be drilled therein three inches deep and then tapped with a five-sixteenths-inch tap to a depth of two and three-fourths inches. A small adjustment in the design would remove the necessity of these relatively costly operations on such a comparatively insignificant unit. The lubricating system of the same automobile was made up in part of a series of drilled holes, many of them drilled at compound angles. In one instance, a three-inch hole had to be drilled to meet a five-inch hole in another part, the two holes being at a compound angle to each other. To the layman, perhaps, this may be meaningless, but to the shopman it means many hours of extra labor working on tasks which must be performed with a high degree of accuracy, with the likelihood of a large amount of spoilage and the assurance of high production costs. A careful study of the product would have suggested ways of modifying the design so as to eliminate much of this difficulty and greatly increase the ease of manufacture and its control.

The selection of equipment.—The selection of machinery and tools is also affected by the results of a thorough analysis of the product. The very simple and obvious illustration of means employed for manufacturing hammers may be taken. The hammer which is sold in the five-and-ten-cent store must be produced at the lowest possible cost and is made by casting the article in a foundry. The ordinary carpenter's hammer, on the other hand, which must stand constant hard usage, is first forged and then ground. The processes involved in making these two grades of hammers are radically different from start to finish and depend on the difference in quality of the finished article.

In some cases it will be found that it is necessary to build a special machine for the production of certain articles, simply because the usual type of machine is too small in some respect. A redesign of the product will often permit the use of the machine regularly employed for this operation with a consequent saving in capital investment.

The design of tools also depends on the nature of the product. If a part made of brass is turned on a lathe, the shape of the tools will differ considerably from that which would be necessary if the part were of cast iron. In some cases, also, special tools may be required because of the design of the part.

The selection of labor.—The kind of product will determine in some cases the kind of labor required. If the product is assembled by hand from small parts, girls are almost always to be preferred to men, for usually they have a deftness and manual dexterity of the kind needed which men in most cases lack. If the parts are to be made with great accuracy, more skill is required on the part of the workers than is the case when the parts have large tolerances and no high degree of exactness is needed in their production.

Internal transportation equipment.—The selection of the internal transportation equipment is conditioned to a very large extent by the kinds of product to be handled. Fluids can often be piped from place to place, but, if this is not possible, water-tight containers are necessary. Materials whose unit weight is large often require crane service; silk hats and glassware, on the other hand, need protection during transportation, lest damage be done to them; while explosives, on the contrary, require protection, not so much on their own account as for the safety of the plant and the workers.

Type of building construction.—The character of the product has an effect on the type of building construction which is required. If the unit weight is large, it may be necessary to make use of single-story buildings. The production of acetic acid must be carried on in buildings other than those made of concrete, for this acid attacks that kind of material rapidly, and the depreciation of the building, in consequence, is very heavy. Textile factories demand a special construction to allow the maintenance of the humidity at a certain degree, no matter what the outside atmospheric conditions may be, because the textile fibers become practically unworkable unless the humidity is high. These are simply a few illustrations of the way in which the kind of product affects the building construction directly. It also has an indirect influence through the type of operation or class of machine involved.

Manufacturing standards.—The establishment of manufacturing standards of all kinds depends to a considerable degree on the finished product. This relationship has already been suggested in connection with materials and equipment, but it also holds true for operation standards. The speed with which a machine may be operated depends in part on the finish which is desired.

The method of holding work in a machine and the motions necessary to insert and remove it depend on the shape of the material, and the fatigue of the workers is affected by the facility with which the article may be handled. All of these factors affect the establishment of the operation standards.

The task of designing the product.—From what has been said, it is evident that the finished product is likely to be studied from many different angles and often with conflicting conclusions. The place where the product is actually designed is usually a designing department of some kind, not infrequently called by that name, or, in the metal-working and allied industries, it is known as the Engineering Department. Here the original design will be worked out and here the criticisms from other interested parties will be gathered, examined, and made use of if possible.

These criticisms from the standpoint of the factory come largely from, or through, the Manufacturing Standards Department, which is responsible for the establishment of operation standards and which should have a good deal of influence over the setting of the material standards, taking into consideration at all times the practical needs of the factory. In fact, as a general rule, no design or specification should be considered final until it has been approved by the Manufacturing Standards Department as a practical production proposition. Nor should the influence of this department on the design of the product be simply negative in its character. Often it is in a position to offer constructive suggestions which are of very real value to the Engineering Department.

In a small concern the Engineering Department not only often prepares the first draft of any new design but also completes the specifications in the form of detail and assembly drawings, the blue-prints therefrom, and bills of material. In the larger companies such functions are likely to be given to separate departments to facilitate the administration of the design of the product. In many cases the Engineering Department is aided by Chemical and Physical Laboratories and by an Experimental Department, where its plans can be tested by the construction of full-size models. In the chemical industries the laboratories are the designing departments and their specifications take the form of chemical formulae.

To a very considerable extent the problem which has been discussed in this chapter is a technical one and demands a thorough technical training and extensive practical experience on the part of any one who attempts its solution. Whether or not the chief factory executive who is responsible for the manufacturing administration of the business is competent to deal with it himself, he should at least recognize its importance, understand the nature of its principal phases, and have sufficient training to be able to work with those who are engaged in its solution.

References for Additional Reading.

Basset and Heywood, "Production Engineering and Cost-Keeping," Chapter IV.

Lansburgh, R. N., "Industrial Management," Chapter XVI.

CHAPTER III

FUNCTIONS AND THEIR CLASSIFICATION

Purpose of this chapter.—To study the functions of a typical manufacturing concern and the relationships which exist among them.

It was pointed out in the first chapter that a business is essentially a group of activities which must be properly coördinated if the concern is to be successful. These various activities are commonly called "functions" and their proper coördination results in the internal "organization" of the business. This organization is the framework of the company, on which all its operations depend. Without it, it is impossible for the business to operate smoothly, for it provides the channel through which the current orders and reports pass. It is especially important in a manufacturing concern that the functions be carefully defined and adequately organized, because otherwise their large number and variety are likely to cause confusion. Many of the activities are intimately related and it is necessary to describe carefully their scope and limits in order to prevent conflict of authority and responsibility.

Three main groups of functions.—In practically all manufacturing concerns, the various activities may be broken up into three main groups: (1) Those which are involved in the actual fabrication of the finished product or, primarily and substantially, are for that purpose only. These may be called the "manufacturing" functions. (2) Those which are necessary to the marketing of the merchandise so produced, and hence may be called the marketing or "distribution" functions. (3) All the other activities which are necessary to the successful operation of a manufacturing company, essential to its proper administration, and whose benefits are felt through the assistance which they give to the two first named groups of activities. This group may be called the "administration" functions.

No matter what the type of business may be—whether a steel company, a hosiery mill, a packing plant, or a machine-tool building company—these groups of functions always exist. In some cases one or another of them may sink to relative insignificance as compared with the others, as when, for example, the entire output of the factory is taken by a single jobber or retailer, and, in certain cases, some of the divisions of one of these groups may be more important than an entire group from the standpoint of the welfare of the company and the difficulty of the problems involved, as when, for instance, the design and development of the product outweighs the whole manufacturing group of functions, as sometimes occurs in the perfumery business. This logical division, which is quite valuable from several points of view, does not interfere in any way with the relative importance of the several functions.

Detailed analysis of the functions.—It will be noted that the approach which has been made to this problem is that which was outlined in the first chapter. That is, the whole business has been analyzed into its principal activities. The same process should be continued, breaking up the principal groups of functions into subfunctions, and so on through to routine methods and detailed operations. The results of this analysis should be classified, weighed and measured, any necessary new elements added, and the whole synthesized into a well coördinated organization.

Typical symbolized classification of functions.—The following table is intended to be typical only, and many variations in details which depart rather widely from the scheme shown here may often very properly exist. It should be noted that the classification of functions here presented is mnemonically symbolized,[1] which aids materially in their use in various ways.

Typical Symbolized Classification of Functions.

- A—Administration Functions.
  - AD—Design and Development of Product Functions.
    - ADB—Blue-print and Photographic Department.
    - ADC—Chemical Laboratory Department.

---

[1] For a discussion of the use of mnemonic symbols with tabulating machine cards, see Moffit Ford in "Industrial Management," reprinted in "Industrial Cost Accounting for Executives," by Paul M. Atkins, McGraw-Hill Book Co., Inc.

    - ADD—Drafting Department.
    - ADE—Engineering Department.
    - ADF—Filing Department (Drawings and Blue-prints).
    - ADP—Physical Laboratory Department.
    - ADX—Experimental Department.
  - AF—Financial Functions.
    - AFA—Accounting Department (Financial).
    - AFC—Credit and Collection Department.
    - AFF—Financial Department.
    - AFP—Paymaster and Cashier Department.
  - AP—Personnel Functions.
    - APE—Employment Department.
    - APJ—Industrial Relations Department.
    - APL—Lunch Room Department.
    - APM—Medical Department.
    - APS—Safety and Sanitation Department.
    - APT—Training Department.
  - AG—General Functions.
    - AGE—Executive Department.
    - AGF—Filing Department (Correspondence).
    - AGG—General Office Department.
    - AGL—Legal Department.
    - AGS—Stenographic Department.
    - AGT—Traffic Department.
- D—Distribution (Marketing) Functions.
    - DA—Advertising Department.
    - DC—Commercial Cost Accounting Department.
    - DR—Service (Customers) Department.
    - DS—Sales Department.
- M—Manufacturing Functions.
  - MA—Auxiliary Manufacturing Functions.
    - MAB—Buying (Purchasing) Department.
    - MAC—Cost (Factory) Accounting Department.
    - MAD—Standards (Manufacturing) Department.
    - MAF—Finished Stock and Shipping Department.
    - MAH—Heat, Light and Power Department.
    - MAM—Maintenance Department.
    - MAN—Inspection Department.
    - MAP—Planning Department.
    - MAR—Receiving Department.
    - MAS—Stores Department.
    - MAT—Tool Manufacturing Department.
    - MAV—Internal Transportation Department.
    - MAW—Watchmen and Fire Protection Department.

MD—Direct Manufacturing Functions.

(These functions should be classified and symbolized to meet the needs of the company in question. In general, they will be classified according to the kind of product worked upon, or according to the nature of the operations performed, or a combination of the two.)

Departments, the functional units of organization.—It will be found in most cases that the unit into which the functions are most commonly grouped for purposes of organization is the department. This marks one very practical stage in the subdivision of the functions; the next is usually the operation in the several departments into which the work of the department is divided.

Functions involved in the design and development of the product.—The first group of departments on the preceding list is that which is concerned with the design and development of the product. The group is worked out on the basis of a rather good-sized metal working concern, and, of course, the names of the departments and the nature of their work would change markedly for other industries. The key department of this group is the Engineering Department. Its task is to design and develop the product. In other words, to furnish the brains for working out new ideas. Its work is largely accomplished when the ideas have taken concrete form in the shape of sketches and all the fundamental calculations have been made, though it also has the duty of following up the ideas which it has originated until they are completed. In doing its work it is necessary for this department to give adequate consideration to the needs of both the marketing and manufacturing problems of the concern.

In its task the Engineering Department should be aided by the Drafting Department, which prepares the working drawings from the sketches which have been given it and completes any supplementary detailed calculations which the Engineering Department has not made. When the final design has been decided upon, the Drafting Department makes all drawings which are needed in the shop for producing the article—detailed and assembly drawings of all kinds—any tracings which may be necessary, and checks all its work to assure absolute accuracy throughout. Once the final drawings are completed, they should be turned over to the Blue-print and Photographic

Department to be blue-printed or photostated and then given to the Filing Department to be filed until needed again.

Not infrequently it will be found that the design of the product will depend in some measure on the kind or quality of materials which may be used. For information of this kind assistance must be sought from the laboratories—both physical and chemical—in which research work in regard to materials may be carried on. Of course, only concerns which have a large amount of this kind of work to do can afford to maintain laboratories for this purpose; but in most cases this same kind of service may be obtained from laboratories which are operated on a consulting basis, so that there is little occasion for doing without this assistance.

In most cases, also, it is desirable to test out any new article before it is definitely decided to proceed with its production and sale. In spite of careful planning and thorough consideration given to every essential detail in advance, the only sure proof of an article is to try it out and discover whether it will act as expected. The Experimental Department should be equipped to produce experimental models and should subject them to all appropriate tests. Often many changes are found to be necessary and several models are constructed before the final design can be approved and work begun upon it.

Relation of the design functions to other functions.—The next question which arises is in regard to the relation of these departments to the others in the company. According to the classification shown here, they are grouped with the general administration functions. The reason for this was suggested in the preceding chapter and is based upon the fact that design of the product influences the solution of both marketing and manufacturing problems, and hence the service rendered by the departments whose immediate concern is designing to both the principal groups of functions. An automobile company offers a very good illustration of this kind of thing, as the design of the car will affect its selling possibilities to a very marked degree, and, of course, will influence its production also.

The majority of concerns probably face just this type of problem, but there are others for whom this problem takes a rather different form. There are some cases, especially in the jobbing type of industry, where the designs are brought to the company in a relatively high state of development, sometimes complete with all needed blue-prints, etc. In most cases, however, the company which is to produce the goods will find it necessary to do not a little engineering work on the job before it can be given to the shops. The large machine tool builders offer an example of this sort. Usually they have very well equipped engineering departments, planned originally for the benefit of their standard line of tools. During the course of a number of years, a great deal of engineering data and information is accumulated by them which is available for the aid of any customer who wishes to have some special machine constructed. Under such circumstances, the customer often brings simply a sketch of what he desires and data respecting the requirements which the machine must meet and leaves it to the tool building company to complete the design and construct the machines. Under such conditions, of course, the designing functions would form a part of the manufacturing group, probably as a separate class coördinate with the auxiliary functions.

The financial functions.—The next group of functions in the classification is called the financial functions. The task of the departments in this group is to see that the company is properly financed, that a correct record is kept of the receipts and disbursements of cash, that the cash is paid out only when properly authorized, and that the company does not accept business from concerns which are not financially sound. These functions should be grouped around the Financial Department, which is composed of the treasurer of the company and his immediate assistants. It is his task to see that the necessary funds are available when needed and that unauthorized disbursements are not made. It is also his duty to frame the financial policies of the concern, and to this end he should prepare a financial schedule. He should be aided, of course, by all managers who have the authority to make expenditures, and especially by the manager of sales through whose efforts most of the receipts come in.

The Financial Accounting Department should keep the general ledger, the voucher register, the sales journal, and the cash book. These are the key books for the control of disbursements and receipts, and they provide a means for recording most financial transactions. The paymaster or cashier handles the actual receipts and disbursements of cash. If the receipts are first recorded in the Accounting Department and then given to him for deposit, and the payroll is made up in the Cost Department instead of being put up and paid out by him, a double check is obtained on the cash. The Credit and Collection Department passes on the credit to be extended to customers and follows up the collection of overdue accounts until it is evident that legal action is necessary.

Industrial relations departments.—One of the most important problems which every industrial concern is facing at the present time is that of its relation to its employees. As soon as the company grows out of the "one-man" class, some kind of mechanism must be set up to aid it in dealing with its employees. This mechanism usually takes the form of a group of personnel departments which provide the contacts with the workers outside of those involved in the performance of their daily tasks. The names given these departments in the classification are all fairly self-explanatory, except, possibly, the Industrial Relations Department. The work of this department consists, in part, of the duties which formerly belonged to what was called the "Welfare" Department, and in part the representation of the management in those contacts with employees through shop committees, etc., which are the result of the effort now being made to find a common ground of mutual understanding for both the workers and the management.

The question may very appropriately be raised as to the desirability of treating it as one of the administration group of functions. In favor of so placing it, it may be said that the problem of industrial relations exists wherever there are employees, and that means throughout the entire business. It may be pointed out, in addition, that the question is one involving general policies, and hence concerns not only the manufacturing functions but all the others besides. On the other hand, in most manufacturing companies—and they are the only ones under consideration here—the larger part of the employees are engaged in the manufacturing departments. In most instances, too, the problem is more acute in connection with these departments than with the others. The length of the period of employment suggests an interesting comparison of the difficulty of the problem as between office and shop employees, for it has been estimated that the average length of employment of an office worker with any one concern is about two years, while that of the shop hand is only about four months. In many cases, therefore, it may be expedient to consider this group of departments as a subdivision of the manufacturing function and place it as a group coördinate with the auxiliary departments.

General administration functions.—The general functions which are grouped under the head of administration include all functions which do not properly belong elsewhere. The names of most of the departments are self-explanatory. The Executive Department should include the general executives of the company, like the president, secretary, the general manager, and their immediate personal assistants. Its primary function is the general control of the operation of the business, and for that reason the system of orders and instructions, as represented by the standing orders and standard practice instructions and of reports, as represented by balance sheet, statement of profit and loss, and other statements from the Financial Accounting Department, and the various reports from the Industrial and Commercial Cost Accounting Departments, and especially the general forecast for the business as represented by the master schedule, should be centralized in this department.

The General Office Department provides for the telephone operator, the office boy, incoming and outgoing office mail, and other services to the various office departments. The Traffic Department should have control of incoming and outgoing shipments, in so far as the company is concerned, until they reach their destination.

Distribution or marketing functions.—These functions form a fairly well-defined group by themselves. There is usually an Advertising Department whose task it is to give publicity to the product of the company by means of printed material, and to obtain inquiries which the Sales Department can then turn into sales. The Sales Department does a large part of its work through salesmen and sometimes through branch offices. It is becoming more generally recognized now than formerly that it is essential carefully to control the costs of distribution. The first step in this direction is to ascertain what these costs actually are, and once the normal costs are determined it is important to measure actual costs against the standard set. The task of the Commercial Cost Accounting Department is to record the cost of marketing and prepare reports therefrom as they may be requested. The Customers' Service Department should provide assistance to the customer, in case he has any trouble with his purchase. Its task may be roughly described as "keeping the goods sold."

Auxiliary manufacturing functions.—The auxiliary manufacturing functions are those activities whose chief reason for existence lies in the aid which they bring to departments which are actively engaged in transforming the raw material into the finished salable merchandise. There is little question but what this group exists, but there may be some dispute in regard to the propriety of locating therein certain departments listed under that head in the present classification.

Purchasing Department.—The first department shown is the Buying or Purchasing Department. Its prime duty is to secure the material which the factory needs for its operation, both material which goes directly into the finished merchandise and that which is necessary for the operation of the factory, such as coal, oil, waste, repair parts, etc. In addition, of course, it buys the materials needed by the other departments of the business as well, and many of the services which the concern may require from outside sources, such as telephone service, light and power, etc. The total of its activities in these respects is small when compared with the amount of attention which it gives the purchase of material for the factory. The satisfactory purchasing of this material requires the very closest connection with the manufacturing departments, both in regard to the kind and quality of the material to be purchased and the quantities and times when these purchases are to be made. To function efficiently, it is necessary for the person in control of this function to have an intimate knowledge of the markets wherein he is buying and of the individual supplies as well. Of course, the acquisition of large quantities of material results in the expenditure of relatively large sums, and hence there must be maintained fairly close contact between the Buying and the Financial Departments.

The task of the Purchasing Department is rather definite, but its location in the classification of the functions is not so evident. Because of the necessity of the closest possible contact between it and the other manufacturing departments, especially the Planning Department, and because the buying of material is really the first step in current production, it is logical, and experience has shown that it is thoroughly practical, to place it where it has been located in the present classification—among the auxiliary manufacturing functions. On the other hand, because of its close relationship to the financial problems of some companies, it may be wise to group it with the financial functions, and in other cases it proves best to set it up alone, coördinate with the other groups which come under the general head of administration.

The Factory Cost Department.—The Factory, or Industrial Cost Accounting, Department has the task of keeping a record in terms of dollars and cents of the transactions which take place in the factory. It is an intermediate link between the records for production control and the accounts in the general ledger. Its records and reports should form an integral part of the general system of internal control whose focus is found in the Executive Department.

Coming as it does between the general accounts and the production control records, its position may be a little ambiguous. If the entire record-keeping activities of the business are set up as a separate group of departments, as is sometimes the case, instead of being distributed among the primary functions and controlled from the Executive Department as seems to be better practice, the Factory Cost Department may be grouped with the General Accounting and Commercial Cost Accounting Departments as a separate group under the general head of administration. On the other hand, it should be recognized that a very large number of the vouchers with which it works comes from the Planning Department, that its prime task is to keep a record of what goes on in the factory, and that a large part of the service which it renders is for the benefit of the factory executives. For these reasons, which are both logical and practical, it is better in most cases to locate it, as has been done in this classification, with the auxiliary manufacturing departments.

The Manufacturing Standards Department.—The task of the Manufacturing Standards Department consists of the establishment of manufacturing standards of various kinds, all of which point particularly toward the operation standards. Standards for materials other than those set by the Engineering Department—for equipment, plant layout, writing of orders, employees, and rates of wage payment—are typical of the standards for which it must work.

Other auxiliary manufacturing departments.—The names of most of the other departments in this group are self-explanatory and need no further elaboration here. The Finished Stock and Shipping Department becomes responsible for the finished merchandise and ships it out as ordered. The Heat, Light, and Power Department has the task of supplying the factory with all the power needed in any form which may be required—steam, electricity, compressed air, etc. The Maintenance Department should maintain the buildings and equipment at the standard which has been determined upon. The Inspection Department measures the quality of the product against the standards which have been established. The Planning Department plans, schedules, and dispatches the work through the factory and records accomplishment in terms of physical units. The Receiving Department receives and checks, and the Stores Department stores and issues all material, whether it is purchased from outside venders or made within the factory. The Tool Manufacturing Department makes any tools which the shops require and which cannot be purchased to better advantage outside. The Internal Transportation Department moves the material from place to place as directed within the factory. The Watchmen and Fire Protection Department has the task of guarding the property of the company against assault from without and fire from within.

The direct manufacturing departments.—The classification of the direct manufacturing functions depends, naturally, on the nature of the business. In general it may be said that in a continuous process type of industry and in the intermittent type which tends to approach the continuous type, the departments will be organized on the basis of the kind of product worked upon without regard to the kind of operation performed, in so far as this is possible. This is in accord, of course, with the principle of carrying the work forward in as nearly a straight line as is possible. In the jobbing type of industry, on the other hand, the tendency is to establish the departments on the basis of the kind of machine employed or the operation done. For example, lathes will be grouped together to form one department, milling machines another, drills another, etc. In this way efficiency of operation is promoted and the maximum output from each machine obtained.

Conclusion.—When the various functions have been analyzed and classified into departments, it is necessary to coördinate them definitely into an organization. Some steps must have been taken in this direction during the process of preparing the classification, but the fragmentary relationships which have been so established need further elaboration. The functionalization and departmentalization of a business and the coördination of the various functions and departments into an organization are steps which are complementary to each other, and both are essential to the welfare of any business.

References for Additional Reading.

Church, A. H., "The Science and Practice of Management," Chapters III and IV.

Jordan and Harris, "Cost Accounting," Chapter VI.

Shaw, A. W., "An Approach to Business Problems," Chapter I.

CHAPTER IV

THE INTERNAL ORGANIZATION OF A MANUFACTURING CONCERN

Purposes of this chapter.—

1. To study the meaning of the organization of the functions of a business.
2. To investigate the more important bases on which a manufacturing business may be organized.
3. To consider practical methods for the organization of a business.
4. To study the relationship of the workers to the organization.

In the preceding chapter the emphasis was laid on the analysis of the activities of a manufacturing business into major groups which were called "departments." It was pointed out that any systematic analysis and classification of the functions implied at least a little putting together of the results of the analysis. The departmentalization of a business, however, is only one step in the direction of making it an efficient tool in the hands of the general manager and his associates. Dividing the functions into departments is like putting papers into pigeonholes—they are segregated; but if the papers are to be put together into an informative report they must be assembled and systematically arranged, and the same thing holds true in the case of business functions—to be effective they must be coördinated and organized.

Organization on the basis of functions.—There is little question but that the organization of a business on the basis of the functions involved is the only correct basis if the various departments are to be coördinated in such a way as to be able to render the most effective service. It is only recently that this truth has begun to receive proper consideration. Most concerns, even at the present time, have a sort of pseudo-organization which is predicated on the relationships which are established, or which may grow up among the various individuals who perform the tasks which are involved in running the business. It is not a case of placing the Planning, Stores, and Internal Transportation Departments under the production manager's authority and making him responsible for their successful operation, but of making John boss over Jim, Joe, and Bill.

Evils of a pseudo-organization.—There is very little which can be said in favor of any such tying together of the functions of the business. In the first place, only rarely are they ever really coördinated throughout. The activities which are under the control of personal friends are frequently very well interlocked, but if the heads of two functions which should be operated in close coöperation with each other are not sympathetic, it usually happens that the "buck is passed" from one to the other continuously without any productive results forthcoming. It frequently means, too, that there is a lack of development on the part of the employees involved, for each is so tied to his job that he cannot find time either to train someone else to relieve him of a part of his task or to fit himself in various ways for a better position. Hence, the opportunity of creating specialists who have, in addition, good general training, is lost. It often results in several men doing the same kind of thing which could be better accomplished if it were concentrated. Three or four individuals, for example, may buy material for use in the shop, and, as a result, money is tied up in inventories which could much better be spent in other ways, or material is wanted and purchases are made in the least economical fashion. In addition to the overlapping of tasks, gaps between them are often discovered, because there is no way of knowing whether all the activities have received proper consideration. All this is due in large measure to the lack of a clear definition of the various tasks to be performed which almost invariably accompanies this hit-or miss kind of business growth.

It may be laid down as a general rule, therefore, which applies to all business, manufacturing in particular, that the organization of the concern should be based on the various functions which the business involves and not on the basis of the individuals, who may happen from time to time to be in charge of these functions.

To say this, however, does not answer all the questions in regard to the internal organization of a company. To state that a business should be organized by the coördination of its various activities as represented by the several departments into which those activities have been grouped does not explain *how* the coördination is to be done, nor does it give any conception of the problem of organization within the various departments which is also important.

Three outstanding types of organization.—Down to the present time there are three outstanding types of organization of a business, or perhaps better, methods of coördination of the functions which have received extensive consideration. They are:

1. Line, or so-called "military" type.
2. Line and staff.
3. Taylor, or so-called "functional" type.

The line type of organization.—In the line type, as illustrated in Figure 2, the activities on any one level are all the same; that is, every workman has just the same kind of job to do, and so on, up to the higher grades. The lines of responsibility run from the lower position to the one immediately above it, and authority passes in the opposite direction. Each group of activities is an integer itself, supposedly sufficient for the tasks which it is expected to perform.

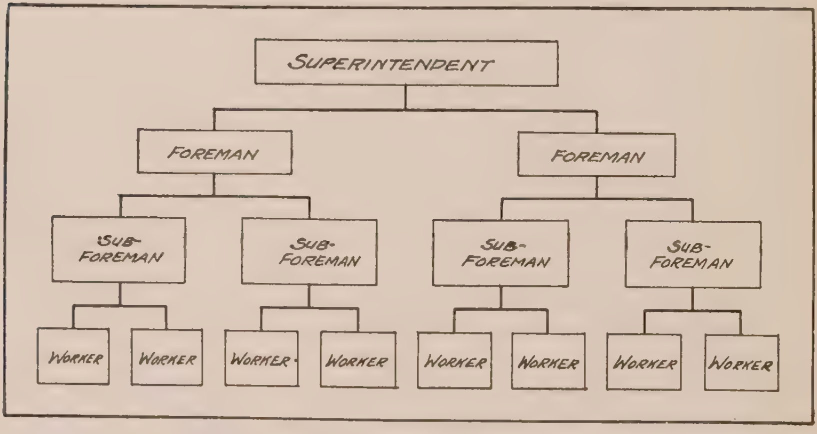


Fig. 2.—Line Type of Organization.

While this type is more commonly found than any other, it is rarely strictly logical in the way in which it is worked out. The two departments which are suggested by the foremen in the diagram are seldom alike—one may be a foundry and the other a machine shop. Nevertheless, it is quite possible to maintain the outstanding features of the line type of organization—direct and inflexible lines of authority and responsibility, lack of differentiation and any more than the most rudimentary specialization, etc. This does not indicate, of course, that the business is not functionalized; it simply means that the various activities are not differentiated to the same extent as is often the case in other types of organization. While this type is very often condemned by writers on the subject of organization, and sometimes very severely, there are few concerns which could get along without having at least the main interrelationships established in the form of the line type, and there are certain very important advantages in connection with it which must not be overlooked. It furnishes a definiteness of authority and responsibility which is often hard to attain otherwise, and which is essential to the smooth and orderly working of the business. It is easy to understand, and, for this reason, almost all the coördination of activities among the lower positions is worked out on this basis.

On the other hand, there are certain marked disadvantages, the appreciation of which has promoted the development of other types of organization, which must not be forgotten. The grouping together of large, undifferentiated masses of activities makes specialization difficult and sometimes impossible. This applies especially to the higher positions in the business, where important questions often demand a highly specialized kind of training which is hard for the occupant of that position to obtain if he must be relatively expert in many matters. The transmission of orders is slow, for it is necessary for them to pass by the regularly established lines of authority and this delays action when sometimes speed is necessary. Many other arguments have been advanced against it, but a careful analysis will show that most of them are really against that pseudo-form of organization on a basis of individuals instead of functions, the undesirable character of which has already been pointed out. So fundamental are its advantages, however, that there are few concerns which can do without a foundation of the line type of organization, though it is not long after the business grows beyond the "one-man" class before a certain amount of differentiation begins, and an accounting department, a purchasing department, a sales department, etc., are set up.

Line and staff type of organization.—An attempt to remedy some of its most obvious faults which center around the lack of differentiation resulted in the setting up of "staff" departments or groups of functions. Typical of these in certain concerns are the Planning Department, the Manufacturing Standards Department, etc. (see Figure 3). These activities are not directly involved in the performance of the primary functions of the business; but indirectly, by providing information which is essential to the line functions, they are of great assistance. Fundamentally they are advisory in their character and furnish the means of developing standards and plans

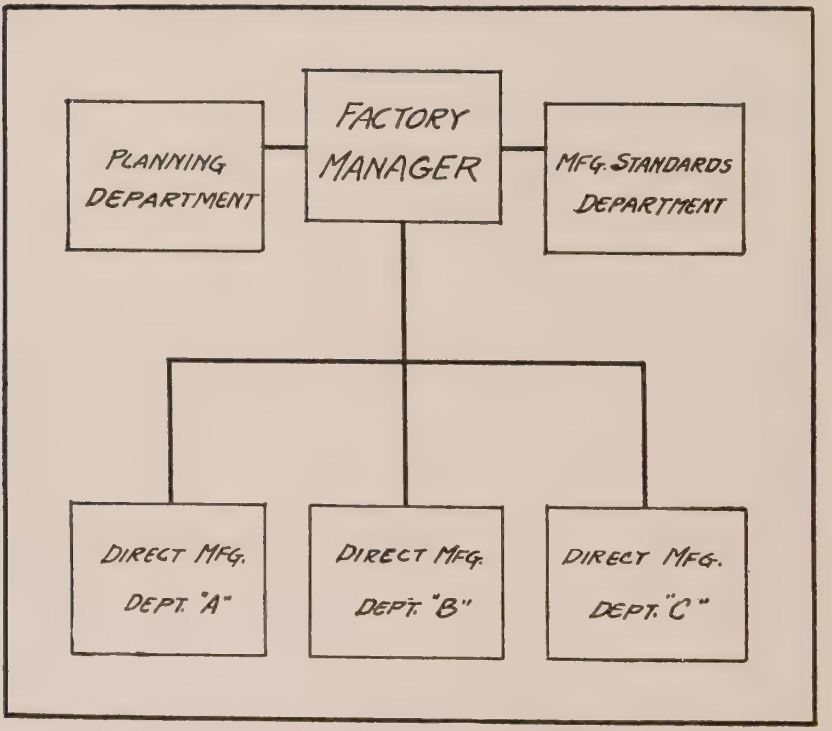


Fig. 3.—Line and Staff Type of Organization.

for which a regular line position leaves no time to its occupant. In the case of the two departments suggested in this connection the Manufacturing Standards Department develops the operation, material, and so forth, standards which are needed in the shops, while the Planning Department employs these standards and the information which it receives in regard to the probable future requirements of the business in planning the production. In many cases neither of them issue orders directly to any of the line departments, but simply make recommendations to the position for whose benefit they have been created. It may be seen that these departments really have parts of the task which, if they did not exist, would be distributed to the superintendent and the foremen under him. The same activities are present in both cases, but they are organized in a different manner, and, in most cases, in a more satisfactory fashion when the form adopted is that of the line and staff.

The great advantage of the line and staff type of organization over the line form lies in the fact that the search for better methods for doing the work and the making of plans for the future are placed in the hands of specialists. They are not concerned with the ordinary routine work of the factory or office, but are free to devote their energies to the handling of the special problems which are presented to them. At the same time the line departments are not bothered with these questions, but are in a position to devote their entire attention to the routine duties of getting the work done.

The great difficulty with this method of coördinating the various activities of the business lies in getting the members of the staff departments and those of the line departments to coöperate. Theoretically there is no trouble in this respect, for any disagreement should be taken at once to the individual who is the superior to both the staff and the line departments concerned and he should settle it. This works all right, if there are only occasional differences which are the results of an honest divergence of opinion; but if the discord is continuous, the superior's time will be taken up with making adjustments, and the work of both departments concerned will lag.

The solution of the problem lies in the selection of men for the positions involved who really wish to coöperate and who recognize their mutual dependence. There is always a tendency, however, for the members of the staff to feel that they know a little bit more about methods and procedure than the members of the line—which should be so, since that is their job, but it isn't always the case—and for the members of the line to think that they are the only real "producers" in the business and that the members of the staff are more or less parasites, which is not true if the staff is doing its work properly. The real key to the solution of this problem lies in the selection of the head of the two groups of departments, for if he is a capable executive he will train the two groups under him to work together, and the benefits of this type of organization may then be retained.

Taylor type of organization.—The type of organization listed is called the Taylor type, because it was developed by the late F. W. Taylor. It was early called the "functional" type, because of the stress which laid therein on the differentiation of the various functions. The name is not, however, strictly applicable, for it has been seen that the other types may use the various functions as a basis. In this type of organization the line relationships disappear almost entirely, and as a result the lines of authority and responsibility cross and recross. This type can best be illustrated by Mr. Taylor's arrangement of the activities of the Planning Department and their relationships to the shop work (see Figure 4).

It will be seen that between the production manager who has general control of production and the worker in the shop there are four minor executives in the Planning Department—route clerk, the instruction card clerk, the cost and time clerk, and the disciplinarian—and four in the shop—the gang boss, the speed boss, the repair boss, and the inspector—each of whom have direct personal relations with each one of a certain group of workers. This type of organization represents the extreme differentiation of the functions, and its chief fault is just that —it carries the division too far to be practical.

The advantage of this type lies in the fact that each person in charge of a function has an opportunity of becoming a specialist, as each function represents a narrow range of activities. In this respect it is excellent, and, when first developed, was a reaction against the very extensive integration of the line type and the evils of the personal basis of organization. Its serious fault is that it so divides authority and responsibility that there is plenty of chance of avoiding both and in actual practice this is what results in most cases. Its success supposes a state of moral perfection that has not yet been attained on the part of the individuals who are to have a part in it. Mr. Taylor performed a very valuable service, however, in stressing as he did the importance of the functions as the units for the organization of a business, and not a few of the present improvements in business organization are the direct outcome of lessons learned from him.

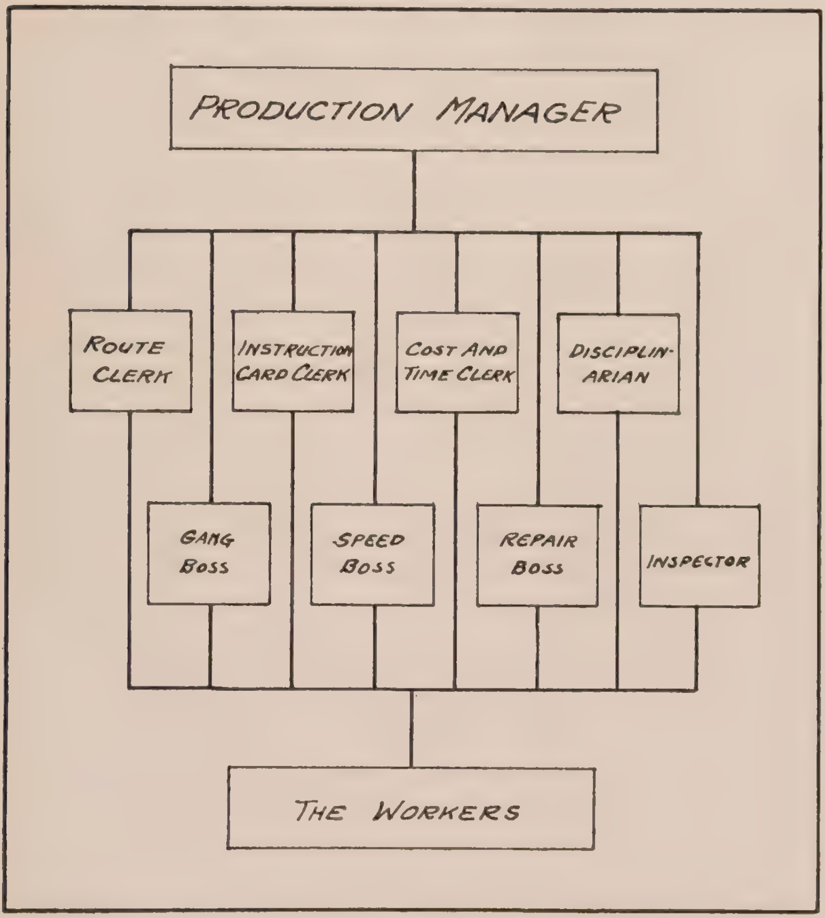


Fig. 4.—Taylor Type of Organization.

Committees and their place in the organization.—It is sometimes desirable to make use of committees which are advisory in their character, and in some few cases it will be noted that committees have executive duties to perform. Under such circumstances, it will be found that a "committee" type of organization is spoken of. As advisory organs, committees often have a very important place in a business; but, as a means of accomplishing a definite, concrete piece of work, they are seldom successful.

In actual practice it will be found that most successful concerns employ various ways of coördinating the several functions of the business, and that the methods employed approximate one type in one section of the business and another, in another section. This is quite proper, for the object which should be sought in all cases is the tying together of the various activities in such a way that the business as a whole may be able to render the greatest possible service, and it is not a matter of any importance whether one type or another is followed throughout. Organization is simply a means of helping the executive with his task, and, while it should be worked out carefully and scientifically, the exact form which it takes is of no vital consequence. A typical example of the organization of a medium-sized manufacturing concern is shown in Figure 5 (p. 43), and it will be noted that there is a backbone of line relationships established to which certain staff departments and committees have been added. An analysis of the internal structure of some of the departments would probably reveal a type of coördination closely resembling the Taylor type. In the vast majority of cases, it will be found that a variety of types may be discovered in a single organization.

Relations other than those of authority and responsibility.—So far, the discussion has proceeded on the more or less tacit assumption that the outstanding relationships to be established were those of authority and responsibility. While this is fundamentally true, it must not be forgotten that there are relationships which should not be overlooked. There is a great deal of routine transfer of information from one department to another, without which the control of the business would be greatly complicated. There are requests for data and reports to be prepared which establish other relationships among the functions. All these, and many other points, must be thought of in connection with the organization of the business. Some of them are suggested in Figure 6 (p. 45).

An organization manual.—It should be obvious that there is a mass of material in connection with the functionalization and organization of a business which will be easily forgotten unless it is recorded in some definite and permanent form. In fact, very many of the difficulties which are encountered

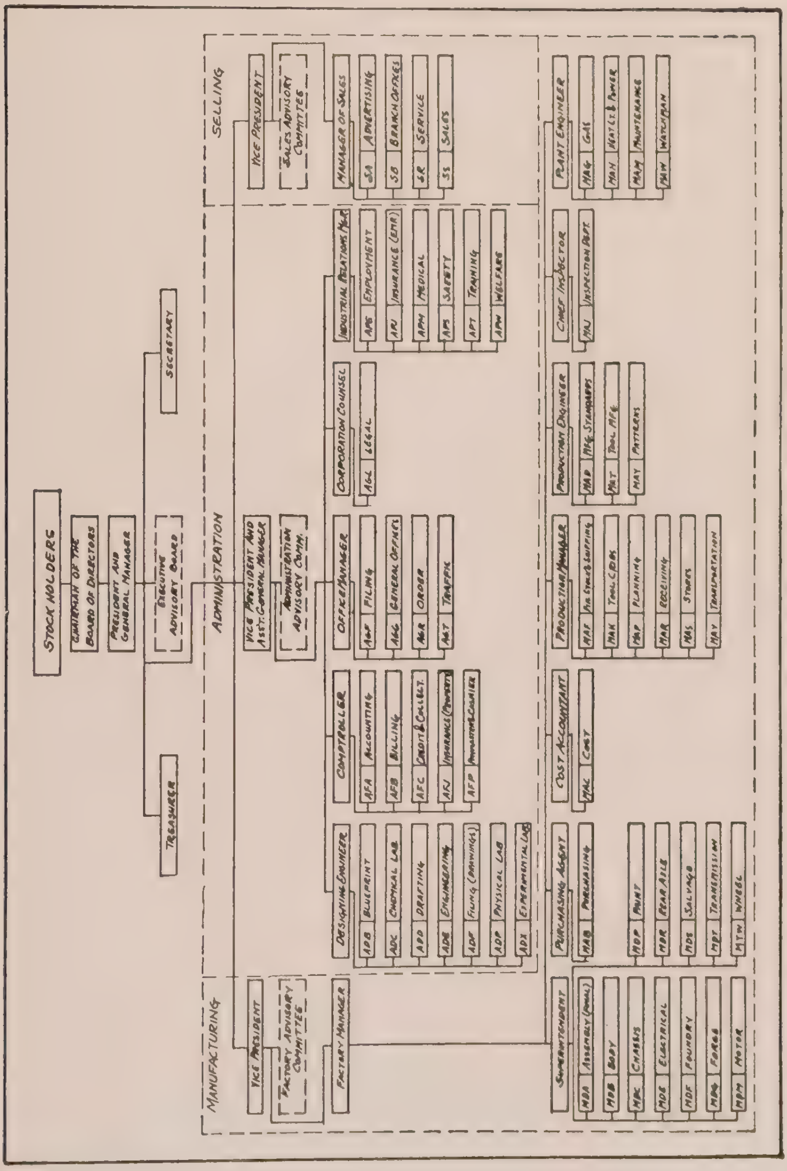


Fig. 5.—Typical Organization Chart.

are due to this very point. There are two ways which are available for meeting this problem. One of these is a written description of the various functions, the extent and scope of each, and their relationship to each other. Such a description should be simply an outline of *what* is to be done and should *not* include an attempt to explain *how* the functions of the several departments are to be performed. Such a record is important also, but it should be prepared separately. This outline of the activities of the various departments and executive positions should clearly indicate the extent of the activities of each and the connections, not only of authority and responsibility, but also all others which may exist among them. In this way a basis is provided for the elimination of the misunderstandings which arise among employees, for, with the description commonly called "an organization manual" before them, there is little excuse for any fundamental mistakes in this respect. As new departments are added or modifications made in the functions of the already existing departments, the appropriate changes should be made in the manual which at all times should be kept up to date.

Organization charts.—The second means for permanently recording the organization of a business is available in the form of an organization chart. Figure 5 is an illustration of the form which this kind of chart should normally take. It will be noted that only the lines of authority and responsibility are indicated in addition to lines which set off the principal functions from each other. It may also be seen that only the more important executive positions, the committees, and the departments are recorded. In this chart a clear conception of the outstanding characteristics of the organization of the business may be obtained at a glance. If lines to indicate the other relationships were shown in addition and the details of the organization of the several departments were included there would be such a mass of material on the one chart that it would be confusing rather than helpful. One of the most important benefits to be derived from such a chart is the view which it gives of the whole business, the details being explained in the organization manual.

To supplement such a chart of an entire business, it is frequently desirable to have subsidiary charts of the major subdivision thereof and of the more complex departments. It is quite possible to show other relationships than those of authority and responsibility on these charts, because of their more limited fields. Often, however, they take the same form as that shown in the larger chart. A better way of showing the various connections among the several departments is that illustrated in Figure 6. A single department which has many and varied relationships is chosen as a basis for the chart and the other departments with which it has connections are grouped around it, while its coördination with them is shown by lines of various kinds. A few charts of this sort for the more important departments are all that are necessary, as they will cover the entire business. Such charts are very helpful in gaining a definite conception of the way in which the various activities are coördinated and should always be available for the inspection of the employees.

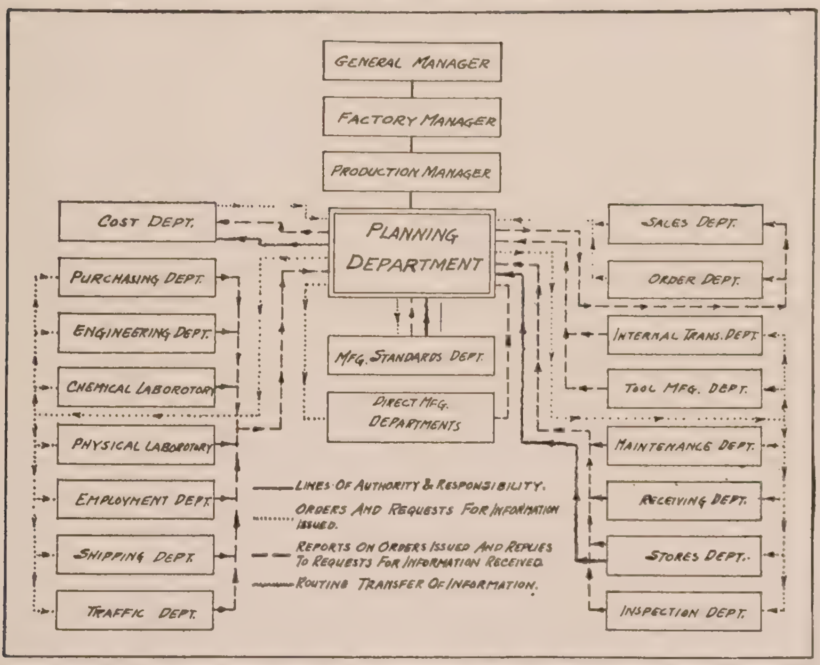


Fig. 6.—Chart Showing Relations Among Functions Other Than Those of Authority and Responsibility.

The place of individuals in the organization.—So far the discussion of the organization of the business has been carried on with only an occasional reference to the individuals who are to perform the various functions. It is quite obvious that no business can exist without the services of employees to do the work and that these services have a very close connection with the organization of the business. In fact, so important a part do they play that they are often meant when the expression, "organization" is used. It is perfectly true that the best organized business—when the coördination of the functions only are considered—may be a complete failure because of the employees. Hence it is evident that due consideration must be given to their place in the organization.

It was pointed out in an earlier paragraph that it was not sound practice to base the organization of the business on individuals instead of on functions. Individuals are constantly changing, while the work which they have to do continues. Having once coördinated the functions the next step is to select the individuals who are to perform them. They should be chosen so far as possible, because of their suitability for the tasks which are to be given them, and, if they are lacking in any respect, the effort should be made to train them in that regard. If the duties involved in any function are too arduous for one individual, two may be provided and the work split between them. If a manager is qualified in all ways except one or two for the tasks which he is expected to perform—unless the lack is in some moral quality—an assistant can often be provided to meet that need. In a small concern, one man may often be the head of two departments, even departments that are not closely related, provided he has the necessary qualifications to manage both. Sometimes slight modifications may be made in the organization to meet the capacities and limitations of the existing personnel, but this should be done with caution and as a last resource. It is much better to train men up to their tasks than to modify the functions and their relationships, because of the insufficiencies of certain individuals. The basis for the organization of any business is its functions, and the units employed are the groups of functions called departments; the organization consists essentially of the coördination of these departments in such a way as to facilitate so far as possible the smooth running of the business by the executives; and, finally, the personnel of the company should be selected to meet the needs of the various functions which have been established.

References for Additional Reading.

Duncan, J. C., "Principles of Industrial Management," Chapter XIII.

Kimball, D. S., "Plant Management," Chapters IV and V.

Porosky, M., "Practical Factory Administration," Chapter I.

Shaw, A. W., "An Approach to Business Problems," Chapter VII.

Chapter V

THE SELECTION OF EQUIPMENT

Purpose of this chapter.—To study the problems involved in the selection of equipment.

Two phases of the problem.—There are fundamentally two phases to the solution of the problem, the selection of proper equipment: (1) ascertaining the needs for equipment; (2) selecting the required equipment from among the kinds already existing or designing new machinery when none is at the moment developed and available.

Analysis of equipment requirements.—To decide what the needs of a particular business for equipment really are is not so simple as it might at first seem. A thorough analysis of the needs is the first step which must be taken. It is essential to go back of the more immediate factors affecting the selection of the equipment to begin the analysis. One of the first questions to ask is whether the business is of the continuous, intermittent, or jobbing type. If it is of the continuous type, then the equipment selected will presumably be used for turning out only one article. It should be designed for the utmost economy of operation, for small savings, many times repeated, mean large profits, and small losses, which come frequently, usually result in a deficit. On the other hand, it is seldom important in this type of industry for the equipment to be adaptable to wide variety of operations or output, since it is to be anticipated that there will be no radical change in the kind of goods produced. Other things being equal, therefore, in the continuous type of industry, machines specially designed for the use required of them are to be preferred to the generalized type of equipment adaptable to many operations.

The needs of the jobbing factory.—If the concern is of the jobbing or engineering variety, on the contrary, practically the opposite may be said in regard to the choice of its equipment, which should be adaptable to a wide variety of production within the limits of the kind of work which the company plans to seek and to accept. If it has only a limited range of uses, there are likely to be times when there is work to be done which is not accomplished because no machine is available, and at the same time machines are standing idle, because they are not adapted to the work which it is necessary to do. Moreover, small losses in operation, due to the fact that the machine is not the best possible selection for the work in hand, are not serious, because they are repeated only a few times. The damage is not nearly so serious as is that which results from complete idleness of the equipment. The intermittent type of industry comes in between these two extremes in its effect on the selection of equipment.

The importance of idle equipment.—The importance of the idleness of machinery is so great in dealing with many factory problems, and especially in connection with the discussion of the present topic, that it is desirable to indicate some of the reasons therefor. To do so, necessitates a brief summary of one of the phases of industrial cost accounting. It is quite obvious that the expenditures for the material which is used in making the finished product and the labor which is involved in transforming it from the raw state to completed merchandise are a part of the cost of the product. It is not quite so evident, but just as true that some portion, at least, of the cost of operating the machine in which the material is processed is also a part of the cost of the output. The machine performs a service to production quite as much as does labor, and as the services of labor involve an expenditure in the form of wages, so also do the services of the equipment involve expenses of operation, such as, depreciation, insurance, taxes, cost of power, of maintenance, of the use of the floor space occupied, etc. Such expenses are called the "burden" which the machine must bear until it is transferred from it to the product when goods are being produced, or canceled as a loss when it is idle.

Under normal conditions, that is, when the factory is working full time, but not overtime, and the expenses of operation are no more than they should be, the burden should all be transferred to the product as a measure of the benefit of the service given it during the time it was being processed. When the machine is idle the expenses continue at practically the same rate as when it is in use. There is no product being benefited by the machine and hence the burden cannot be charged thereto. If men are idle they can be laid off, but there is no way of stopping the expense which is incurred by the machine and which, therefore, is a complete loss to the company. Any cause of idle equipment results in the loss of unearned burden, which must be charged against the profits of the business just as surely as would the loss caused by the failure of a customer to pay his bill, or the loss caused by the destruction of the plant by fire. When the fact is appreciated that idle equipment means a constant and steady loss for every hour of idleness, often amounting to $4 or $5 an hour, and sometimes running as high as $10 or $12 or even more, the importance of keeping the equipment busy will be more fully realized and the necessity of making a wise selection of equipment so as to reduce idleness will be understood.

Development of the product.—The stage of development of the product is another factor which has a good deal of bearing on the problem of the selection of equipment; it is one whose significance is often overlooked. If, for example, the product is a new one which has just been designed and whose probable future is still very problematical, it is not generally well to equip a factory heavily with specialized machinery. It is quite possible that the article will not find the demand which was expected for it, and hence, its output must be kept low, or the initial interest in it may prove to be ephemeral, or, if it is successful and the demand for it increases, it is quite likely to be developed in such a way as to necessitate radical changes in the methods of production and hence in the kind of machinery required. Under such circumstances, it is desirable to employ standard machinery which can be turned to other uses if the goods are unsuccessful or the methods to be used are fundamentally altered. Thus any losses which result will be kept at a minimum. There are numerous examples of new products being produced in a radically different fashion after a short period of time. The automobile and airplane industries offer some excellent illustrations of marked changes in design due to the evolution of the product.

If, on the other hand, the goods have reached a relatively high stage of development, then it becomes desirable to select that highly specialized equipment which will permit production at the lowest unit cost. Cotton sheeting, nails, screws, etc., are examples of products of this kind which have not been modified in any extensive way for a long time and which probably will not be changed to any extent for some time to come.

Of course, it may be suggested that it is quite easy to make a statement of this kind, but how, in any particular case, is a manager to know whether the product which he has under consideration has reached a relatively high state of development or not. It is a difficult question to answer, and, in part, any reply depends upon a very careful study of the history of the product and of similar products to date, and in part on the executive's estimate of the future based on whatever information his sales manager and designing engineer can give him. Just because the question is difficult and uncertain in its character is all the more reason why this factor should receive very thorough consideration.

The development of the manufacturing process.—The discussion of the stage of development of the product leads very naturally to the question of the stage of development of the process or machinery which is employed in carrying on the process. The probable future development of the equipment will have the same kind of effect on the question of the choice to be made as does the present stage of development of the product. The production of aluminum is an illustration of what is meant here. Not many years ago the processes involved in its production were so expensive that it could be used for only a few purposes; now it is produced by the ton through a different process which has greatly reduced its cost.

Character of the product.—Whether the product under consideration is a novelty or a staple article has a great deal of bearing on the present problem. If the article is a novelty, then it should certainly be made on standardized machinery of the most adaptable variety so that when the craze for the present article dies, the equipment could still be used for making other things. In such cases, it is advisable to employ hands rather than machines for the production of this class of goods. On the other hand, if the product is a staple, these arguments do not apply, it being better to employ specialized equipment in order to obtain low unit costs.

In some cases the parts may be roughed out on an engine lathe, while in other instances they must be ground to a high degree of accuracy on a grinder. The equipment necessary for producing high-grade parchment or bond writing paper differs in many respects from that needed for the fabrication of kraft or newsprint papers.

The available labor supply.—The kind of labor which it is expected will be available is also a factor in the solution of this problem. If the labor is only semi-skilled, ease of control of the machine is an important consideration. The large influence which workmen who at best can be called only semi-skilled have had on the wide extension of the use of semi-automatic machinery like the turret lathe is an example. In general, it may be said that relatively highly trained workers are necessary for hand-controlled machinery where the quality of the output depends upon the skill with which the control is exercised and for automatic machinery where the principal task—other than supplying material and removing the product which, of course, can usually be done by unskilled workers—is the adjustment of the machinery and the care necessary for its proper maintenance.

The rate of production.—The quantity of production in any given period is another factor which must be given consideration, for, if the quantity of production will not be sufficient to keep specialized or automatic machinery constantly occupied, then it is usually better to use standard machinery for which the output will be less, but by the use of which the cost of operation will be greatly reduced.

The matter of the quantity of production must be taken into consideration along with the sequence of processes which it will be necessary for the goods to follow in the course of their production. It may very well happen that the use of an automatic machine may make possible the performance of a whole series of operations in a single sequence, each of which would require a separate operation on a hand-controlled machine.

The integration of equipment.—This leads directly to another question which can best be considered in connection with the two preceding ones. It is essential that the equipment of an entire department or factory be integrated: Integration means that the various units be so selected that there will be just sufficient of each kind of machine to care for the output which is to go through the others also. Failure to balance the machinery in this way results in "bottle-necks" as they are called, that is, machines or groups of machines whose output is so limited that they hold up the production of the entire shop.

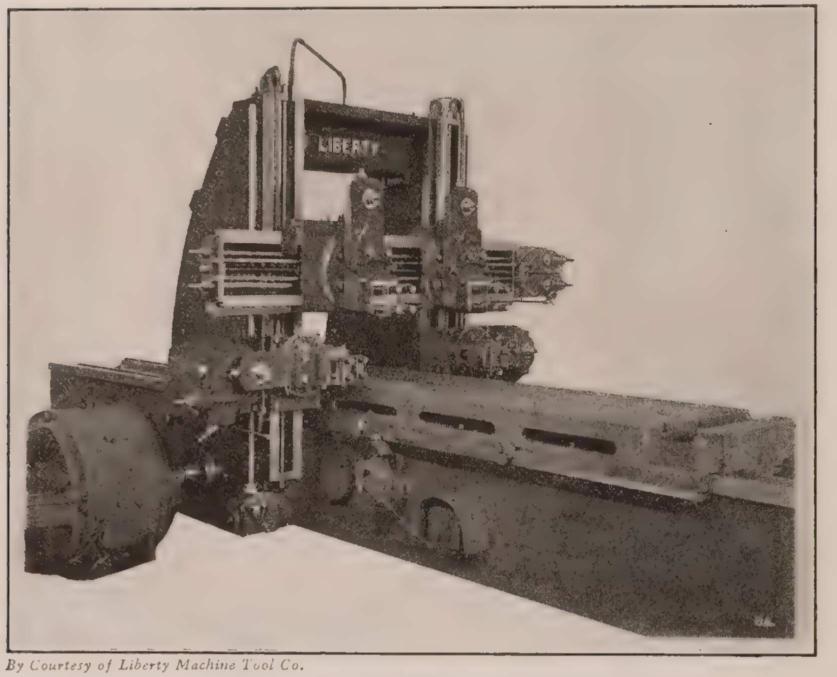
The size, weight, bulk, etc., of the product will have a good deal of influence over the size of the machines to be selected. Often this factor presents special problems, particularly in the jobbing shop where it is desirable to choose machinery which will allow as large a range of sizes as possible. The "gap-lathe" is an illustration of how this problem may be solved in a particular case.

Analysis of available equipment.—The preceding paragraphs contain suggestions concerning some of the more general and outstanding factors which should be considered in analyzing the needs for equipment and the probable effects which the results of the analysis are likely to have. The next step is to analyze the various means of meeting those needs which are available or which may be made available. The object of this analysis and the following measuring of the elements considered is to make possible a selection of machinery which will give the lowest costs of production. Some of the more important factors in the study of existing equipment may be summarized briefly as follows:

1. First cost.
2. Cost of installation.
3. Rate of depreciation.
4. Cost of accessories.
5. Cost of repairs.
6. Cost of power.
7. Cost of lubrication.
8. Cost of cooling fluids.
9. Methods of holding work.
10. Methods of control of operation.
    a. Hand-controlled.
    b. Semi-automatic.
    c. Automatic.
11. Safety.
    a. For operator.
    b. For machine and work.
12. Vibration.
13. Adaptability to various jobs.
14. Rate of output.

15. Balancing with other equipment.
16. Kind of labor required.
17. Amount of space occupied.
18. Fire hazard involved.

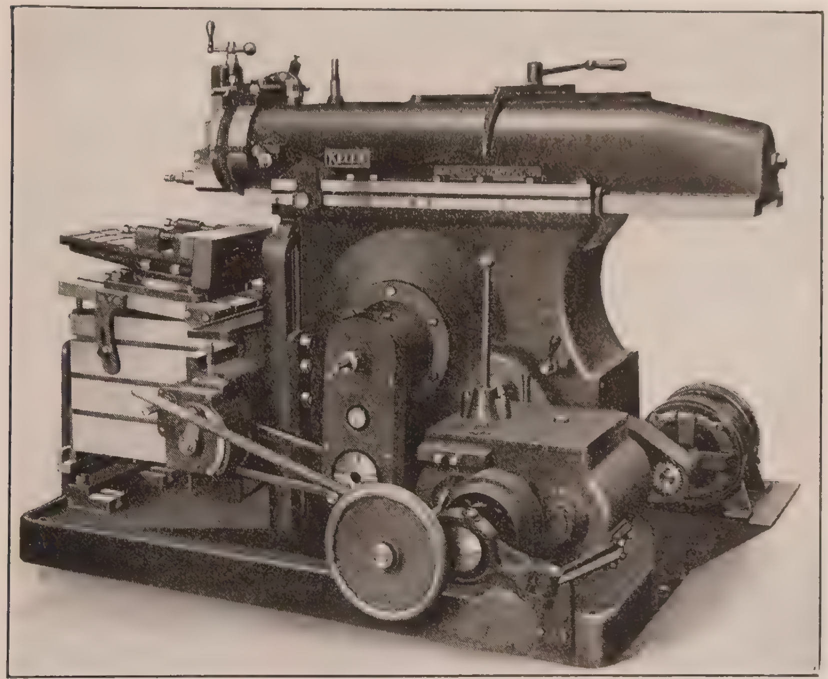
The final measure of the desirability of procuring a certain machine is the cost which it involves as compared with the income which it will produce. Hence, the various factors which affect cost are the ones which must receive primary consideration. As all the factors involved have some bearing on cost in one way or another, it is evident that all of them must receive proper treatment. The starting point for the analysis for prospective equipment is, from the engineering point of view, to discover whether the machine is technically possible for the work which must be done. During the course of the analysis, certain machines which at first seemed to be unable are more or less automatically eliminated from consideration because they are evidently not fitted for the tasks which they would be expected to perform.



By Courtesy of Liberty Machine Tool Co.

Fig. 7.—Planer.

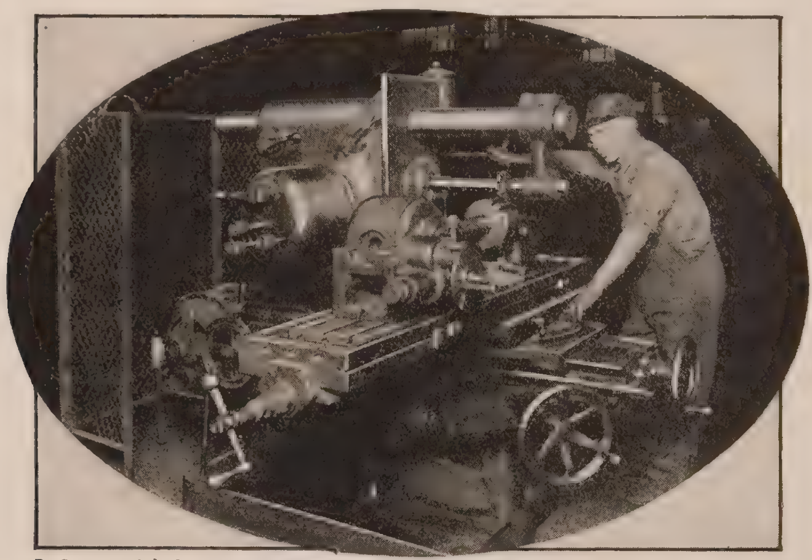
Analysis of cost factors.—Once the technical factors have been weighed, it becomes necessary to give attention to the costs which are involved. It not infrequently happens that the machine which seems best from the engineering point of view is not the right one to select when the effect of the cost elements is considered, especially in connection with the financial policies of the company. The long-run cost is the cost which must receive emphasis, and this sometimes means that the more expensive machine from the standpoint of first cost will be selected unless such a choice is prevented because of the financial conditions and prospects of the concern.



By Courtesy of the R. A. Kelly Co.

Fig. 8.—Shaper.

A good illustration of a practical problem of this kind may be found in the case of a decision as to which machine to choose from among a planer, a shaper, and a milling machine. (See Figs. 7, 8, and 9.) All of these machines are so designed as to be capable of producing plane surfaces. For certain kinds of work, there is no question in regard to which would be chosen, because each can turn out a particular class of work for which it is peculiarly adapted better than the others. For certain jobs, however, each might from the purely technical point of view be just about as efficient as either of the others. It is then that the cost elements come into play and on the basis of what their analysis reveals a choice will be made. Such a comparison is often complicated by the variety of work which it is desired to produce on the machine selected, and hence the complexity of the costs involved.



By Courtesy of the J. T. Ryerson & Son.

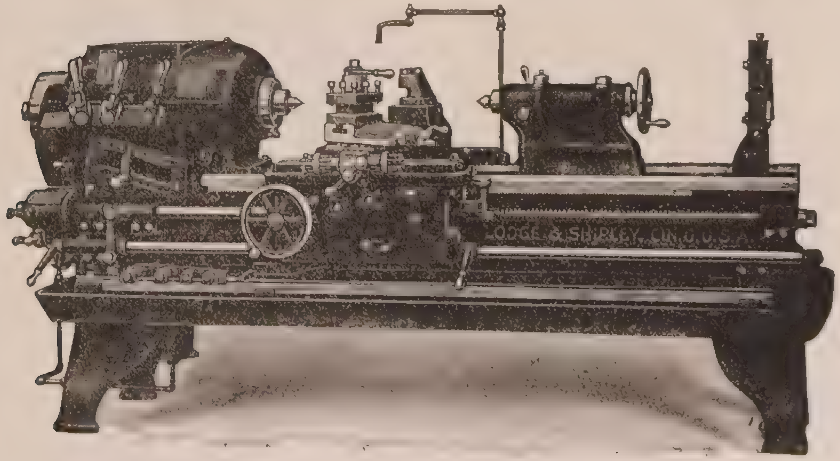
Fig. 9.—Universal Milling Machine.

Standard and special machinery. — From one point of view machines may be classed as standard and special, and the choice must be made between the representatives of the two groups. It is rather hard to draw a fixed line between them, for they tend to shade off into each other; but the two extremes are very clearly different in many respects. The standard machine is one which ordinarily can be bought in the open market or readily can be built to order from already existing plans. It is characterized by its adaptability to a variety of work, the ease of its installation, its relatively low first cost, and its high market value, if, for any reason, it becomes desirable to dispose of it later. Usually, however, it will be found that for any given operation it is not so efficient but is more expensive than a machine especially designed for the particular job. It is also more likely to be hand controlled and less automatic in its action than the specialized machine.

The specialized machine, on the other hand, is less adaptable; its first cost is greater and its market value is relatively lower than is the case with the standard machine. But it is usually more efficient for the operations which it can perform.

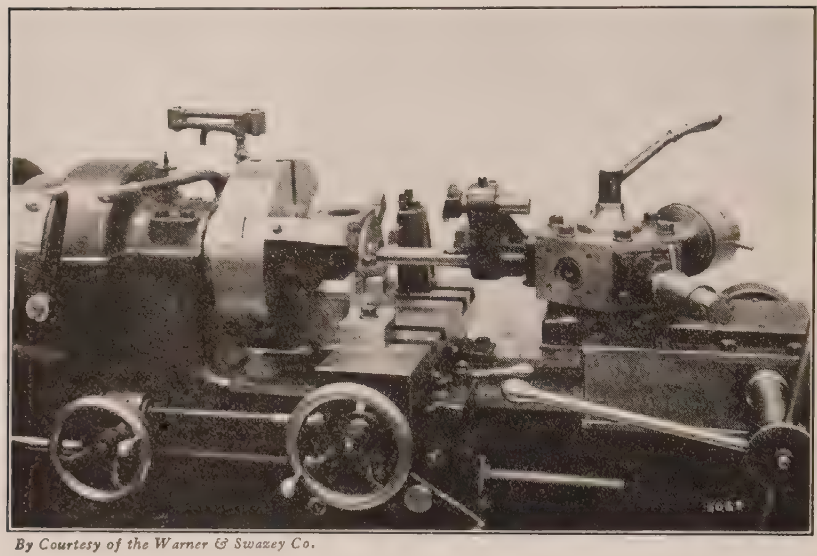
In general, then, the standard machine is the machine for small-scale production, jobbing, and certain kinds of intermittent industry, fabrication of an undeveloped product, and so forth, while the specialized machine is better for large-scale production, the continuous process type of industry, standardized, well-developed product, and so forth. Very frequently it will be found that the needs of any particular case seem to demand both types of machine at the same time. In such a case it is necessary to weigh the various requirements and see whether the emphasis is on the standardized or specialized type. If the two sides seem to be quite evenly balanced the good judgment of the executive must be called upon for a decision. In some cases, the demand for an intermediate class of machine has been felt to be so great that it has been developed.

This problem may be illustrated by three types of lathes—the engine lathe, the turret lathe, and the automatic lathe (see Figs. 10, 11, and 12). The engine lathe is an excellent example of a standardized, generalized type of machine



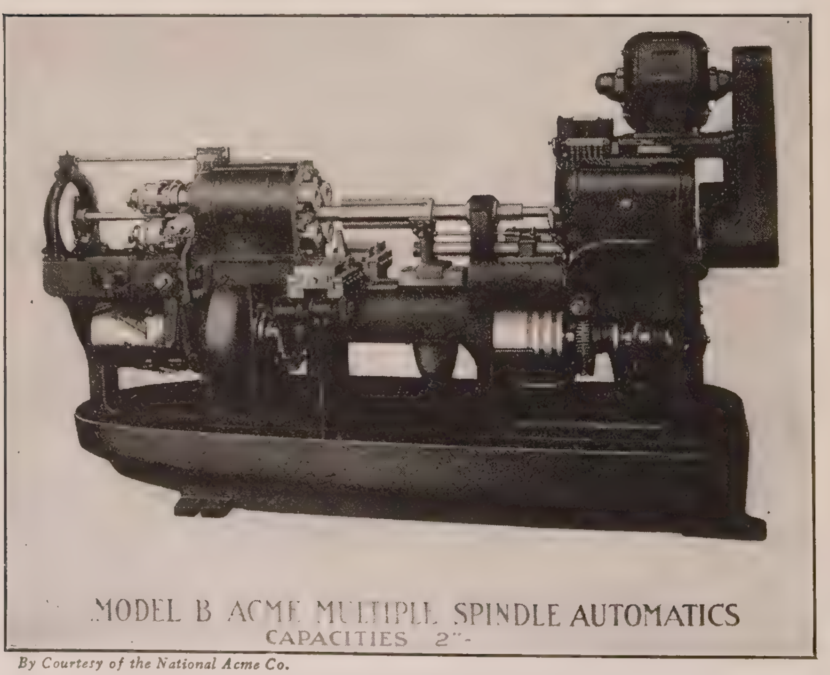
By Courtesy of Lodge & Shipley.

Fig. 10.—Engine Lathe.



By Courtesy of the Warner & Swazey Co.

Fig. 11.—Turret Lathe.



By Courtesy of the National Acme Co.

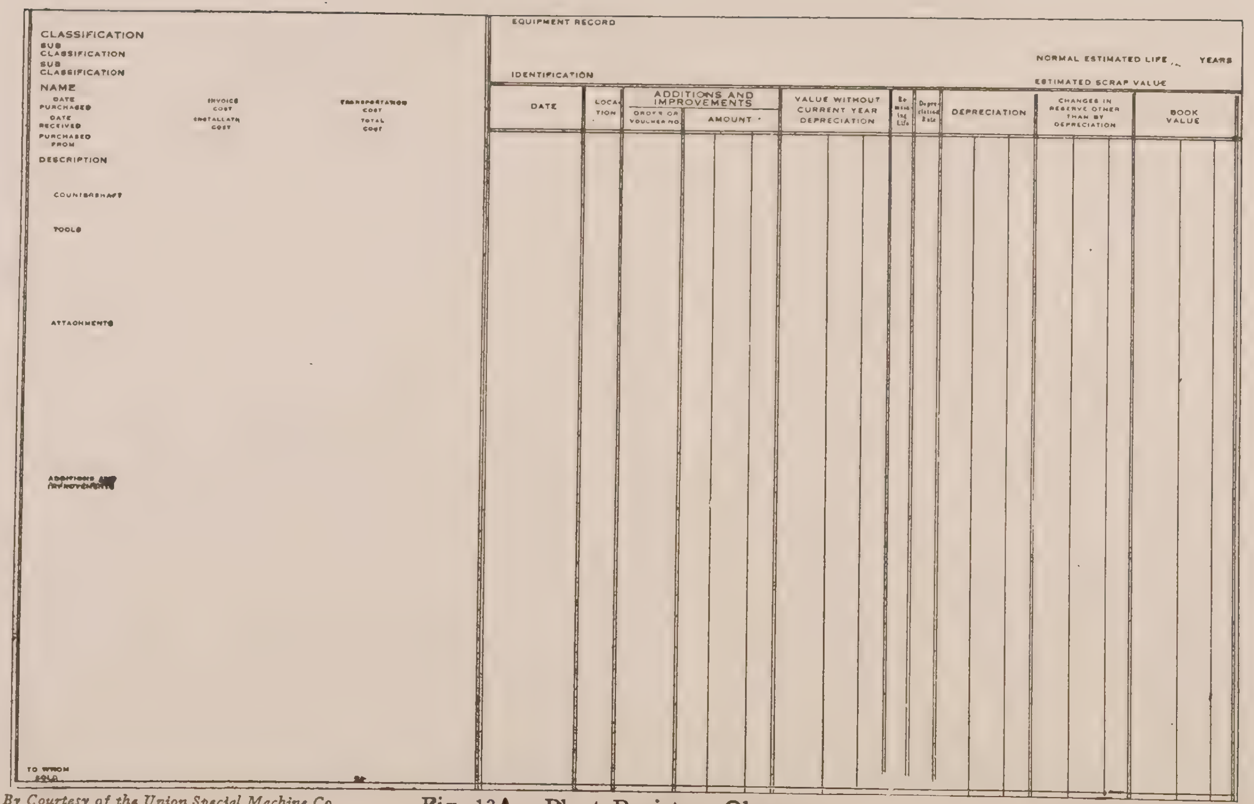
Fig. 12.—Automatic Screw Machine.

capable of performing a very wide variety of jobs which involve metal turning in one way or another. It can take material of many different sizes, is easily set up, and is very largely hand controlled. The automatic lathe, on the other hand, can take work of a rather limited size only, but it is fully automatic in its action. In between the two comes the turret lathe, the essential characteristics of which are shown in the illustration.

The relationship between standard and special machinery.—In most cases it will be found that the first design of a machine limits its uses rather narrowly—in short, it is a specialized type of machine. Then, as its development proceeds, it becomes capable of taking a larger and larger variety of work, but its efficiency of operation does not increase in proportion. At last the need is felt for a machine of its type which is adapted with especial care to some particular job, so another specialized machine is designed which, in turn, begins its development toward a standardized form. This is very well illustrated in the case of the machines under discussion. The automatic and turret lathes are direct outgrowths of the engine lathe. Neither are so generalized in their forms or applicability as the engine lathe, but both are developing in that direction. This is especially noticeable in the case of the automatic lathe which is fast getting out of the class of the specialized machines into that of the standard machines.

The plant register.—After the equipment has been selected and installed, it is important to see that an adequate record thereof is maintained. Such a record is called a plant register and is illustrated in Figure 13. The classification of the machine should be shown, its location in the plant, its accessories and attachments, and any improvements which may be made on it from time to time. It will also be noted that spaces are provided in which may be entered a record of any value changes, such as depreciation, extensive repairs, improvements, etc. Such data are compiled by the Cost Department.

The basis for action on the part of the executive.—In dealing with the problem of the selection of equipment, it is essential for the factory executive on whose judgment the decision depends to be familiar with the general policies and plans of the business, especially in so far as they concern production. It is also important for him to have sufficient techni-



CLASSIFICATION
SUB CLASSIFICATION
SUB CLASSIFICATION
NAME
DATE PURCHASED
INVOICE COST
TRANSPORTATION COST
DATE RECEIVED
INSTALLATN COST
TOTAL COST
PURCHASED FROM
DESCRIPTION
COUNTERSHAFT
TOOLS
ATTACHMENTS
ADDITIONS AND IMPROVEMENTS
TO WHOM SOLD

EQUIPMENT RECORD

IDENTIFICATION

NORMAL ESTIMATED LIFE ... YEARS

ESTIMATED SCRAP VALUE

DATE	LOCATION	ADDITIONS AND IMPROVEMENTS		VALUE WITHOUT CURRENT YEAR DEPRECIATION	Remaining Life	Depreciation Rate	DEPRECIATION	CHANGES IN RESERVE OTHER THAN BY DEPRECIATION	BOOK VALUE
		ORDER OR VOUCHER NO.	AMOUNT						

By Courtesy of the Union Special Machine Co.

Fig. 13A.—Plant Register—Obverse.

RECORD OF REPAIRS				RECORD OF REPAIRS			
DATE	ORDER OR VOUCHER NO.	DESCRIPTION	AMOUNT	DATE	ORDER OR VOUCHER NO	DESCRIPTION	AMOUNT

Fig. 13B.—Plant Register—Reverse.

cal training to be able to understand the mechanical features of the machinery. There is a wide difference between being adequately prepared to design new equipment and knowing enough about the fundamentals of engineering to be able to comprehend a design which has been made. It is the latter qualification which the factory executive should possess in order to be able to deal successfully with the present problem. He should be familiar with the fundamental principles of physics, chemistry, and metallurgy, of engineering mechanics, kinematics, strength of materials, and machine design and the ways in which those principles are applied in current practice. He will then be in a position to evaluate the needs in question and the existing means of meeting those needs.

The selection of equipment requires the careful consideration of the factory executive, for, as it was pointed out in the opening paragraphs of this chapter, the effects of the decision which is reached are likely to be felt for a long time. On the basis of the choice made depends the solution of many of the other problems of factory administration, and hence the problem of choice demands early attention. The selection of equipment is a basic problem which all manufacturing concerns must face.

References for Additional Reading.

"Library of Factory Management," Vol. II, Chapter XI.

CHAPTER VI

POWER PRODUCTION AND TRANSMISSION

Purposes of this chapter.—

1. To consider what the power needs of a manufacturing plant are likely to be.
2. To study the means of securing the required power.
3. To investigate methods for the transmission of power.

A particular kind of equipment—that which is needed for power production and transmission—is here under consideration. It is a question for which, in one form or another, every factory executive must find an answer. In some cases, it is true, where the company purchases its power from a central power station, the problem presents only minor difficulties. In other instances, however, it is one of the most important factors in the manufacture of the product and may even be the deciding element in the location of the plant, as happens with nitrate factories, aluminum producing plants, and concerns making artificial abrasives where the supply of electric power is the first consideration.

The nature of the power problem.—To a considerable degree, the problem is technical in nature and no factory manager should attempt its solution on his own responsibility without special training. Even if he has had a course in engineering, it is wise for him to secure the assistance of consulting power plant engineers, for there are few ways in which losses may more easily and inconspicuously be incurred than in the generation and distribution of power. The control of production depends in large measure on the constant and regular supply of power. If, for any reason, the power is shut off, the machines are idle, with the attendant losses due to unearned burden which were briefly outlined in the preceding chapter. Schedules are deranged and the operation of the whole factory seriously interfered with.

Ascertaining the power requirements.—In dealing with this problem, the first step to be taken is an analysis of power needs. Until those needs are at least approximately determined, it is impossible to make any selection from among the means which may be available for supplying that power. The various ways in which power is likely to be consumed may be outlined as follows:

1. Production centers (machines, etc.).
2. Auxiliary equipment (cranes, pneumatic hammers, portable electric drills, etc.).
3. Light.
4. Heat and ventilation.
5. Miscellaneous (unavoidable power losses, etc.).

In most cases by far the largest part of the power consumed is that which is required to operate the various production centers—the places where work is done directly upon the product. Machines, such as lathes, planers, drills, looms, flour-grinding machinery, stamping mills, etc., are the kind of equipment which is commonly thought of as production centers, and it is quite true that in the grand total of power consuming devices, this class of equipment bulks large. It does not include, however, all the different sorts of production centers which are likely to be encountered in a factory. Nickel and silver-plating tanks, ovens for baking enamel, annealing ovens, furnaces, and hot glue-pots, may all be production centers or parts of production centers, and often they consume more power than do large-sized machines.

The measurement of probable power consumption.—The first task, then, is to measure the probable consumption of power by each of the production centers. If the machines are actually installed and in operation, the measurement can be made directly by means of dynamometer readings. In most cases, however, this is not possible, for the power requirements must be provided for at the time the equipment is installed.

The simplest way to obtain an idea of the rate of power consumption of any production center is to use the statement of the manufacturer of the machinery. Although such statements are a little inclined to be favorable to the machine in question because based on favorable shop conditions which are not often realized in actual practice—though perhaps they should be and can probably be more closely approximated than they are now—such statements in regard to power are usually substantially correct and can be relied upon. At least they are useful in checking any calculation which the user of the machinery may himself make. They usually give the extreme limits of power consumption and hence in a jobbing shop where the extreme limits of the capacity of the machine may be reached, they may be employed as the basis of power consumption calculations. In the continuous process type of industry, especially where the concern is operating on a large scale, such a basis of power calculation is often quite unsatisfactory because the machines may utilize regularly only a portion of the power which they would require if they were loaded to capacity. Under such conditions, it is essential to make further computations which will take into consideration the probable actual rate of power consumption.

Fluctuations in power consumption.—It is also important to ascertain whether the rate of consumption of power is steady or fluctuates from time to time. Changes in the rate of consumption due to the seasonal nature of the industry is one fluctuation which has an important bearing on the means employed to obtain power. It may prove desirable, for example, to plan to produce only that portion of the power which is consumed regularly and to draw on a central power system for the peak periods, though this plan may prove to be expensive due to the character of the load.

The fluctuations may be daily in their character due to the necessity of heating cold ovens in the morning. After the desired temperature has been attained, it requires less heat in a given period to maintain it. Still another fluctuation which occurs with much greater frequency is that which is due to the rapidly changing demands of the machine itself. This type is well illustrated by the punch press or power operated shears. In much of the work which is performed by these machines, the machine is acting only a small portion of the time, the remainder of the time being taken up with putting the material properly into the machine or in getting it out. In the case of the punch press, under some conditions the dies come together a number of times a minute, so rapidly, in fact, that the demand for power is substantially continuous as it is being stored up in the flywheel when not actually being applied to the dies. In many cases, however, where there are only two or three strokes a minute or less, there are very appreciable extents of time when little power is being used. If the necessary power for a battery of punch presses on this kind of work is calculated on the basis of the maximum amount of power which each press would require, far more power will be provided for than will ever be used, even after a large margin of safety has been provided, due to the fact that only a few of all such presses will be using the maximum quantity of power which they are capable of consuming at any one time. Here is a case where it is almost always wise to use a gang motor to drive a group of machines, for the output of the motor may be much less than the maximum capacity of all the machines, but as it would only be by rare chance that all the punch presses would require power at the same time, such a motor can be used without any difficulty, thus saving both in the first cost of the motor and the current consumption of power obtained.

Power consumption by auxiliary equipment.—In some factories auxiliary equipment of various kinds, especially the internal transportation equipment in the form of elevators and cranes, consumes a very appreciable amount of power, and often the demands of such equipment are quite variable. Hence, they must be estimated very carefully and a large margin of safety provided. Another problem is frequently raised in this connection. For lighting purposes and for the running of constant speed motors, alternating current is preferable, not only because of its low cost, but because of its ease of transmission. For cranes and elevators, however, where a variable speed of operation is needed, it is usually necessary to employ direct current motors. Hence, in computing power requirement, it is essential to take into consideration the necessity of transforming the alternating into direct current.

Other auxiliary equipment is sometimes found, such as pneumatic hammers, portable electric drills, etc. Although the total amount of power consumed by them is usually not large, it is, nevertheless, desirable not to overlook it, especially the probable losses of power in transmission which, in the case of pneumatic equipment, are frequently quite heavy.

Power consumed for artificial lighting.—The consumption of power for light, usually in the form of electric current, is likely to be subject to sharp seasonal fluctuations. In the summer, only a minimum amount will be used, for those places where it is necessary to employ artificial illumination, regardless of season or weather conditions, will be the only places where it will be consumed regularly. In the winter, on the other hand, it is customary to light the factory by artificial means for a certain portion of each day, and in dull, cloudy weather during the whole day. It is necessary, therefore, not only to determine the rate of consumption of power but the times when it is to be used, for the use of power for lights affects the seasonability of the power problem to a considerable extent. The amount of power consumed for this purpose depends in part on the design of the building and the provision made for natural lighting, and the proximity of the buildings to others, a phase of the question which is especially important in cities.

The consumption of power for heating.—It must not be forgotten that the heating problem is largely a matter of power, for heat is simply one form of energy which is called power when it is applied at a certain rate to the doing of useful work. The amount of heat required depends on the outside temperature, the nature of the work being done—foundries, for example, need a much lower temperature than do assembly departments—and the shape and construction of the building. Heat is necessary during only a portion of the year, and, even in winter, demand for it varies according to the kind of weather experienced. Even though exhaust steam is used for heating, there is a certain additional amount of power required, for the exhaust steam if it were not so used could be employed in economizers and the engines could be run condensing instead of non-condensing.

Ventilation is closely allied to heating when it appears in connection with the power problem. If natural ventilation is used, no power is, of course, needed; but when artificial ventilation is employed, power is necessary to run the fans and blowers and to wash the air. In some cases, also, it is needful to cool the air in summer, and in all cases where refrigeration in the factory is needed, as in the meat-packing plants, power is consumed for that purpose. All such consumption of power must be carefully calculated.

Most of the ways in which power is used in a factory may be classified under one or another of the groups which have been described. There is at least one other way in which power is consumed which must enter into the power calculations, namely, unavoidable losses in transmission. There are many losses which are not at all necessary, and which should be eliminated; but after everything has been done to reduce losses to a minimum, there are still some which must be accepted and for which allowance must be made.

When all the various ways in which power may be consumed have been enumerated and the calculations for each made, the total amount of power which must be provided can be ascertained and a basis is so established for the determination of the best way of procuring it.

Any decision in regard to means to be employed should be predicated not only on the total amount of power to be consumed but on the times when it is wanted, the form which it may take—electricity, steam, compressed air, hydraulic pressure, etc.—and any local conditions, such as the presence of natural gas, proximity to water falls, etc., which may have an especial influence over the device made.

Obtaining power from a central power station.—The simplest way of obtaining power, looked at from the point of view of the factory manager, is to purchase it from a central power company. Barring serious accidents to the plant of the power company and its transmission lines, and strikes, the supply of power is reasonably secure. Under many conditions this source is the best one to call upon, especially in the case of the small manufacturer. The production of power on a small scale is relatively costly, economy of production increasing with the size of the power plant. In addition to such power being less expensive, particularly for the small factory, the company is relieved of many technical problems for whose solution a consulting power plant engineer is often necessary and for whose services the small concern would be obliged to pay more heavily in proportion than would the large one. Such questions as the time of the company's peak load in relation to the load of the power company, the amount of power consumed, etc., have not a little influence over the cost of the current and hence over the desirability of using this source.

Other sources of power.—The principal means of obtaining power which are open to the concern which must develop its own are:

1. Water power.
2. Steam power.
    a. Reciprocating engine.
    b. Turbine.
3. Internal combustion engine.
    a. Gas engine.
    b. Heavy oil engine.

Hydro-electric power.—Until recent years the first of these was the most important, but with the introduction of steam it has fallen to distinctly a second place, and probably will always remain in that position in so far as the production of power by individual plants is concerned. To be economical, power from this source must be produced in large quantities and for this reason the use of water will probably be confined largely to central power stations where as a source of power its importance is very rapidly increasing. Few companies require power in sufficiently large quantities to make it desirable for them to invest in power production on the large scale which is essential to economy.

In practically all installations for the development of power from falling water, the energy of the water is transformed into electric energy and so transmitted to the place where it is to be used. In general, therefore, in thinking of the development of water power, it is necessary to think of the problem as the hydro-electric generation of power.

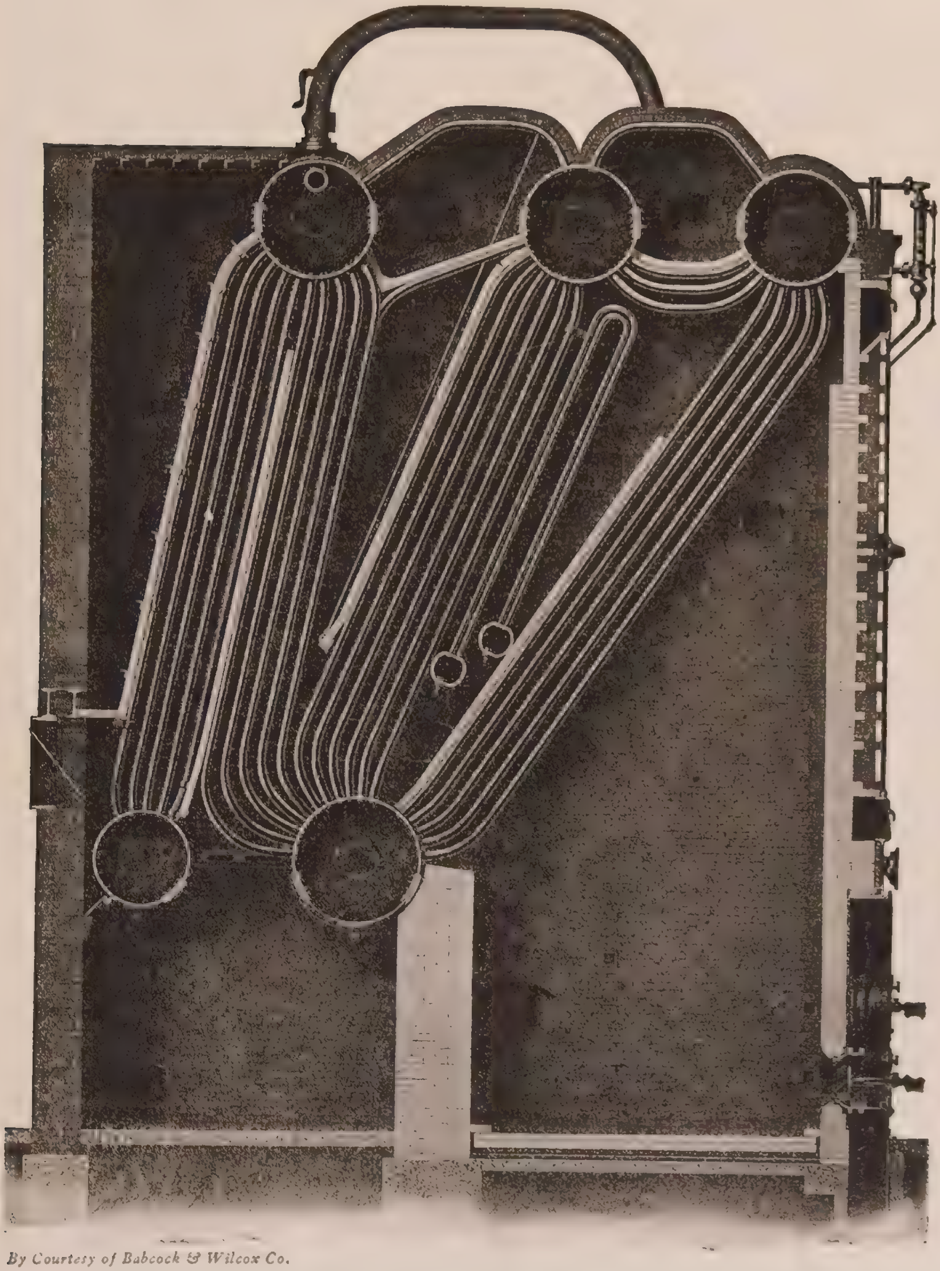
Because of the commercial difficulties in transmitting electric energy any very great distance and because of the cost involved, the current must be consumed in the general vicinity of the place where it is produced, though it is by no means necessary to locate the factory right at the falls as was the case before the development of the use of electricity. Many factories purchase power produced by this means from public utility companies, but few produce it by this method for themselves.

Steam power.—A much more generally used source of power is steam. In this case the latent energy in the fuel is transformed into mechanical energy at the flywheel of the engine. From this point it may be transmitted directly by mechanical means to the machine where it is to be consumed, or it may be further transformed into electrical energy and in this form transmitted to the place where it is to be used. Here it is either employed directly as electricity or transformed again back into the mechanical form in order to motivate the machinery.

There are two large units composed of smaller units for the production of power by this means—the boiler and its accessories for the production of steam, and the engine for the conversion of the heat energy in the steam into mechanical energy. The problems involved in dealing with these units are largely technical, but there are certain general phases of the whole matter with which any factory manager should be familiar.

The boiler and its accessories.—The boiler is a device in which water is converted into steam by the external application of heat. There are many different kinds of boilers, each of which has its own merits and defects, the choice among them depending largely on local conditions. In general, they may be divided into water-tube and fire-tube boilers according to whether the water or the heat is conducted through the tubes. A very simple and clear illustration of a water-tube boiler is shown in Figure 14. In the simplest types of boilers, the water is heated to the boiling point and then converted into steam within the boiler. Such a process is not economical for a variety of reasons, and so, in the large and better installations, feed water heaters are provided in which the water is heated to a temperature very near the boiling point before it enters the boiler. In most cases they are operated with exhaust steam from the engine and pumps, or with condensed steam in the case of condensing engines. Under some conditions it is desirable, in order to heat the feed water, to make use of the heated gases of combustion which pass up the chimney. The device used for this purpose is called an "economizer." Care must be exercised not to block up the flues too much, if the draft is not to be interfered with, nor must too much heat be taken from the gases, if a natural draft is to be relied upon.

Water purification.—In addition to serving as a means for heating the water before it passes into the boiler, feed-water heaters are also sometimes used for the purification of the



By Courtesy of Babcock & Wilcox Co.

Fig. 14.—Water Tube Boiler.

water. If they are not so employed, a separate device is frequently used for this purpose. All water except that which has been distilled with extraordinary care is chemically impure. The impurities consist in part of various salts in solution which do no harm to animal or vegetable life but which, on the contrary, are often very beneficial. When such salts are taken into the boiler, they are not vaporized when the water is turned into steam but are deposited. Their harmful effect is experienced in one or the other of two ways. They may simply be deposited within the boiler and become a kind of insulation against the transference of the heat of the fuel to the water and steam, or they may actively attack the material out of which the boiler is constructed and, in time, destroy it. Either result harms the efficiency of the boiler operation, and is to be avoided if possible.

Wherever it is possible to do so at a reasonable cost, such impurities should be removed before the water is allowed to enter the boiler. The commonest way of doing this is to treat the water with chemicals which react with the salts in the solution to form solid substances which are precipitated out in the feed-water heater or purifier. From these places they can be removed from time to time without any serious difficulty. It is usually impossible to remove all such impurities and so, from time to time, the boiler must be cleaned. In addition to the inorganic impurities there are often organic impurities which must also be removed by filtration or some other means.

Impure water for the boiler means inefficient operation and excessive costs. The water should be carefully analyzed by a chemist to determine its composition and it should receive a treatment according to the findings of this analysis. This whole matter is often overlooked, especially in small plants where there is no technically trained man to take charge of the production of power. It is a point in regard to which the factory manager should be informed and concerning which he should not hesitate to obtain expert advice.

Superheaters.—In many cases, especially in the larger power plants, it is advisable to heat the steam to a higher temperature than it has when it leaves the boiler. This process eliminates any water which may be carried along with the steam and hence reduces the possibility of trouble which might come from water collecting in the pipes leading to the engine or in the cylinders of the engine. It also increases the steam's pressure and hence its effectiveness in the engine.

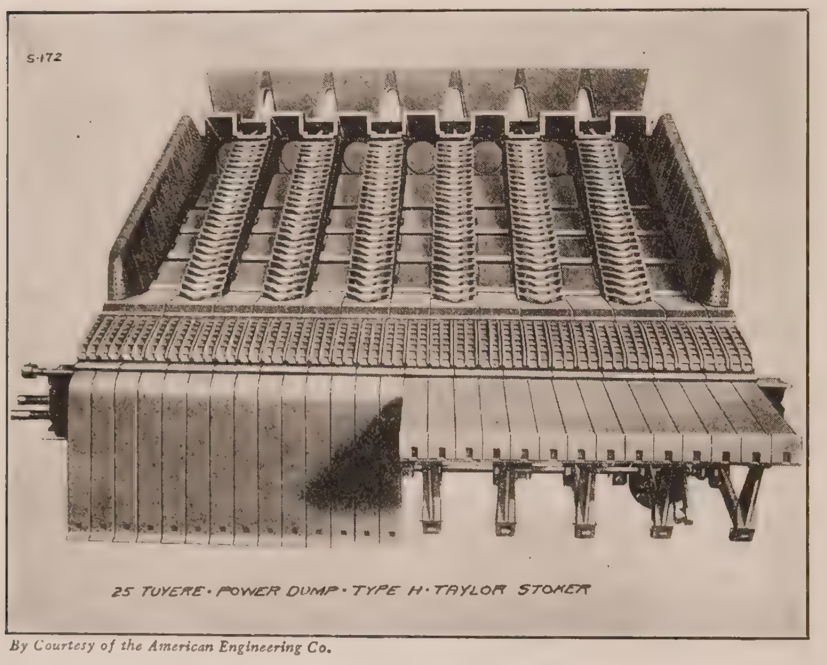
In addition to the boiler accessories already noted, there is a great deal of necessary piping, pumps for the feed water, and other devices whose chief connection is with the boiler.

The boiler furnace.—The largest single operating cost of any steam power plant is the fuel and hence it is most important that it be used to the best possible advantage. It is evident that the design of the boiler and especially the design of the furnace in which the fuel is burned deserve thorough consideration if economy of plant operation is to be obtained.

The object to be attained in the design of a furnace is the complete combustion of the fuel—in most cases, coal. This combustion must be obtained in such a way as to provide for the maximum transference of heat from the fuel to the water. For small boilers there is little question but that this type of firing is the best available, though it leaves much to be desired. In larger installations, specially designed furnaces and automatic stokers are commonly used.

To obtain proper combustion, it is necessary to provide the right quantity of air so that all the combustible elements may be oxidized to the fullest possible extent. To furnish an insufficient supply of air means that the combustion will not be complete and hence the full heat value of the fuel will not be obtained. If too much air is admitted to the furnace, it will be necessary to heat the unconsumed gases and there will be so much less heat available for the production of steam. The quantity of air depends on the quality as well as the quantity of the fuel to be burned. To determine the quantity of air to be admitted, therefore, it is necessary to know the chemical composition of the coal used.

Automatic stokers.—There are a number of automatic stoking devices which are constructed on various principles. One type is the sprinkling variety which allows the coal to drop down on the fire from above. Another variety is the chain-grate stoker. Here the coal is fed on at the front of the grate which moves slowly toward the back of the furnace at such a rate that the coal is all burned before it reaches the rear and there remain only ashes to be automatically dumped. Still a third variety of automatic stoker is that represented in Figure 15. Here the coal is fed up from below, being pushed forward by rocker arms which gradually push the coal forward and up through the fire and then, as it is consumed, down and back to the rear of the furnace where the ashes are automatically dumped. This illustration also shows very clearly how the amount of air to be admitted to the furnace may be regulated.



By Courtesy of the American Engineering Co.

Fig. 15.—Automatic Under Feed Stoker.

Combustion.—The combustion of the coal in the furnace consists of a series of chemical reactions, a number of which are going on at the same time. When the coal is first heated, the hydro-carbon portion is distilled off and burned and then the combustion of the carbonaceous portion takes place. The combustion of all these substances consists of their combination with the oxygen of the air in the furnace at a rapid rate. When a furnace is hand fired, it is difficult to control the relative proportions of the air and of the substances; hence combustion is often incomplete and smoking is frequently the result, the black portion of the smoke being mostly finely divided coal held in suspension by the gases.

The products of combustion are solids known as ashes and clinkers, which must be removed from the furnace at frequent intervals, and the gases, of which carbon dioxide (CO_2) is the most important. The gases are carried away through the chimney. A tall chimney is best because it delivers the gases high above the ground thus avoiding damage to persons and property. Furthermore, if a natural draft is to be relied upon, a tall chimney furnishes that, the drawing power of the chimney depending on the difference in temperature between the gases at its base and the outside atmosphere at its top. In some cases, especially in large power plants, an artificial draft is employed which is developed either by suction or pressure.

The choice of fuel.—The choice of fuel is a very important matter and on the selection made depends to a considerable extent the design of the furnace and the type of the boiler. The various kinds of fuel available in this country are chiefly different varieties of coal, ranging from anthracite on the one hand, to lignite on the other, though industrial plants near the oil fields often use oil fuel to advantage. What is wanted when buying fuel is the heat which it contains, and hence it should be bought on the basis of the number of B. T. U.'s (British thermal units) which it contains rather than on a tonnage basis. It should be remembered in this connection that at the same price for a given number of B. T. U.'s, it is cheaper to buy the high grade rather than the low grade coal—unless the distance from the plant is much greater in the case of the high grade coal—for there are fewer tons to move and hence lower transportation costs, less ash to handle, fewer clinkers to clog the grate, and greater advantage and economy in stoking. The best coal for power plant purposes in this country is the semi-bituminous coal from Virginia, West Virginia, and Maryland.

It is almost always necessary to provide for the storage of at least a few weeks supply of coal, and provision must be made for storage space and equipment to handle the coal. If large quantities of coal must be kept for any length of time the problem is somewhat more complicated, as there is always some danger of spontaneous combustion, a danger which becomes a very vital hazard in the case of certain varieties of coal. Under such circumstances, provision must be made for the ventilation of the coal piles by piercing them with ventilating pipes. The best method is to store the coal under water but such a plan is costly and cannot be used in the winter in the northern portion of the country.

Steam engines.—While steam may be used as power while it is still in that form, as is the case with steam-hammers, in most instances the energy which it possesses must be changed to the mechanical or electrical form before it can be utilized. This means that it must be used in a steam engine in order to effect the desired transformation. In industrial plants the kinds of steam engines which are most commonly employed are the reciprocating and the turbine. The former is much the older of the two from the standpoint of practical application to manufacturing needs, and is still the more frequently used, though in large plants the latter is rapidly gaining in popularity.

The reciprocating steam engine.—The general principle on which the simple reciprocating engine operates is very simple and is familiar to every educated person in the form of the locomotive. The steam is admitted through a valve at one end of a cylinder and presses against a movable piston forcing it toward the other end. After the piston has been moved a certain distance, this valve is closed but the piston is still pushed on by the expanding of the steam. All this time a valve at the other end of the cylinder has been open to permit the escape of the dead steam. When the piston reaches the end of the cylinder opposite to that from which it started, the exhaust valve at the second end closes, the one at the first end opens, the intake valve at the second end opens, and the process just described is repeated. As the piston is securely fastened to a piston-rod, the latter moves with the former. A connecting rod is fastened at one end to the piston rod and at the other to the crank of a fly-wheel and in this way the reciprocating motion of the piston is converted into the circular motion of the flywheel. From the flywheel the power may be taken off by means of belts, chains, or ropes, or it may be geared to an electric generator and electricity produced.

Engine accessories.—Of course, a steam engine is composed of many other parts in addition to those just mentioned. One of the most important subassemblies is the aggregation of parts which compose the valve gears, the mechanism for controlling the movement of the valves. There are also various devices for controlling automatically the speed of the engine and for lubricating the moving parts. One of the most important of the engine accessories which is used for all except the simplest of steam engines is the condenser. As the atmosphere exerts a pressure of about 15 pounds per square inch, the exhausting steam is retarded to the extent of this pressure and hence that amount of power is lost. The condenser provides for the immediate condensation of the exhaust steam to water which occupies only a small portion of the space taken by the same quantity of steam. In this way, a partial vacuum is produced as the steam escapes, and as a consequence the back pressure is greatly reduced.

After the steam has passed through one cylinder there is still a great deal of heat energy left in it, especially if it has been superheated. It is not infrequently conducted, therefore, to a larger cylinder and allowed to expand still further. Sometimes it is conducted to a third and even a fourth cylinder or set of cylinders before it is finally permitted to exhaust into the condenser. Such engines are called double, triple, and quadruple expansion engines, though the latter are seldom used outside of marine engineering. All these cylinders usually act on the same crank shaft and so a more constant torque is maintained than would otherwise be possible. In the care of single expanding engines, two or more cylinders may be arranged in tandem, or parallel, to act on the same shaft in order to obtain the same effect.

The economy of operation.—The more complex types of engines are the result of the efforts to obtain increased economy in the production of power by the use of steam. One illustration has already been given to show how only a portion of the latent energy of the coal is transformed into the energy of the steam. Only a small portion of the energy of the steam becomes available as usable power. Experimentation has demonstrated that only about four per cent of the energy in the coal used in certain power plants is available at the switchboard. The largest part of the losses are due to the transformation of energy into the heat form and from that form to the mechanical. In other respects, the steam engine is mechanically efficient.

The steam turbine.—While the reciprocating steam engine derives most of its power from the expansion of the steam and only a very little from its motion or kinetic energy, the steam turbine produces power by making use of the kinetic energy of the steam principally, and only indirectly of its expansion. In the steam turbine, the steam is directed against a set of vanes or blades which either are movable and turn under the impact of the steam and so produce power, or else are fixed so as to cause the part of the mechanism to which the steam nozzles are attached to turn. In either case, circular motion is produced which can easily be used as a source of power for machinery. In most cases the steam turbine is used to operate an electric generator which is usually mounted on the same shaft with it. Such a combination is very satisfactory, as the economical speeds of operation of both turbines and generators are about the same.

The reciprocating engine and steam turbine compared.—There seem to be distinct fields of service for both the reciprocating and turbine types of steam engines. With the reciprocating engine, the power can be made economically in much smaller units than with the turbine, and it runs, in general, at lower speeds, which is a great advantage if direct, mechanical drive of machinery from the flywheel is to be employed. Its speed can be regulated, and its operation, in general, requires less training than does that of the turbine. It occupies more space, however, and is not so efficient for large units of power production as the latter, especially when electric power is desired. The desirability of the selection of one or the other depends largely on local conditions which should be thoroughly revealed in the analysis of power needs.

The internal combustion engine.—There is still another source of power which is available for industrial plants—the internal combustion engine. There are two classes of these internal combustion engines—the gas engine and the heavy oil engine. There are two kinds of gas engines—the four cycle and the two cycle. The four cycle has been popularized through the automobile. It is more commonly used in this country than the two cycle gas engine. The internal combustion gas engines are more efficient in their utilization of the latent heat of the fuel than are the steam engines; but unless the fuel for them can be secured as a by-product as in the case of the steel mills, or as cheaply as a by-product as in the natural gas and crude oil regions, they are much too expensive for general use. They are clean, they have no waste products which are hard to dispose of, and as small auxiliary units to help in carrying peak loads or to help in an emergency, they are very useful. Also, where fuel is cheap, they can be built of large size to advantage.

In recent years another type of internal combustion engine, using heavy crude oil, has been developed. The outstanding example of this type is the Diesel engine. This engine is designed on a somewhat different principle from that on which the ordinary gas engine is based. It consumes a heavy, crude oil which is less expensive than most forms of fuel for the gas engine, but still too expensive in most places to make it available for general industrial use.

Power transmission.—When the power has once been produced at the flywheel of the engine, there still remains the problem of transmitting it to the place where it is to be consumed. In the days before the development of electricity, some mechanical means had to be employed, and in the older factories these means of transmission are found in active use. Even to-day, there are occasionally conditions when it is desirable to employ them. In most cases, either a belt or a rope is used to carry the power to a main line shaft, pulleys and belts or ropes and sheaves being utilized to transmit the power to the machine where it is employed productively. Even when electricity is used, belts, pulleys, and shafts are still in use to a considerable extent to carry the power from gang motors to the several machines which they drive.

Rope drive.—There are two types of rope drives which are commonly used. One is the American type which employs a single rope passed a number of times around the grooved sheaves which are keyed to the shafts they are mounted on, and then around an idler pulley which is weighted so as to keep the tension in the rope constant. The other type is the one used in Europe. In it several ropes are used, each passing once around each sheave, the tension being maintained by proper splicing. The American system is more easily rigged and the tension is more even, but, if the rope breaks, the whole transmission system is out of commission till it is repaired. In the European system, one or even more ropes might break but the wheels can be kept turning till the end of the day and the repairs made at night. One of the great advantages of using a rope drive, of especial importance before the introduction of electrical transmission, is the fact that power can be carried around a corner quite conveniently by means of it.

Belts.—Most of the belts which are used in factories are of leather, though many are also made of webbing and webbing covered with rubber. The latter kind is especially valuable when power must be transmitted in a department where there is a great deal of moisture or fumes of various kinds. The splicing of the belts must be done with great care so as to provide the proper tension. As the belts stretch in use, they must be respliced from time to time so as to allow the tension to be adjusted to normal. For satisfactory service, belts must not be too tight or too loose. If they are too tight they cause unnecessary wear on the bearings of the shafts which they connect and dissipate power in useless friction. If they are too loose, power is lost through slippage. It is interesting to note in connection with the discussion of belts that in his development of his system of scientific management, the late Mr. F. W. Taylor devoted a great deal of attention to belting problems. The results of research which have served as a starting point for the further work of others may be found in his "Notes on Belting."

In conjunction with belts, pulleys and shafting are necessary. Most pulleys are "crowned," or have a slightly larger diameter in the middle than at the edges. This is to aid in preventing the belt from running off the pulleys. If it is necessary to move a belt from one pulley to another as in starting or stopping a machine, then the pulleys so used should have perfectly cylindrical surfaces.

Belts are often employed where other means might be used with greater efficiency, because of the factor of safety which they furnish. If an unexpected load is thrown on them they will ordinarily slip and then come off the pulleys thus bringing the machine to a stop and often avoiding serious accidents to both men and equipment.

Shafts.—Shafts for the transmission of small amounts of power are usually solid; those for carrying large amounts are customarily hollow, as in this way strength and lightness are both combined. If they are to be successful, great care must be given to their proper alignment. If they are out of line, serious losses of power are encountered.

Gears.—Gears of various kinds are also often used, but mainly in the transmission of power from one part of a machine to another and in the control of the relative motion of the various members of a mechanism. They are seldom found in the line between the prime mover (steam engine) and the machine. Link belts and chain belts of various sorts are also employed to advantage in the transmission of power, especially when considerable change in the speed of rotation is desired.

Electrical transmission.—At the present time, power is most commonly transmitted for all except the shortest distances by means of electricity. In some cases, the source of this power, from the point of view of the individual concern, may be the central power company, but in many instances the electricity is generated by the company itself through the use of steam, as has already been described.

There are two kinds of electric current in common use—the direct and the alternating. The second is the less expensive to produce and the easier to transmit; it is quite satisfactory for use with constant speed motors and electric lights. In many factories, therefore, it is the only kind generated. In some cases, however, it is necessary to have variable speed motors and electro-plating may be one of the processes involved in the manufacture of goods. Under such conditions, it is necessary to have direct current. This may be produced by a separate generator, or alternating current may be transformed into direct current by means of a rotary converter.

Both kinds of currents are produced in generators which are operated either by water turbines or steam engines of one kind or another. The kind of current produced depends on the design of the generator. The current so developed is then transmitted by wires to a motor where it is converted to the mechanical energy of rotation. In some cases, each machine has its individual motor, and in other cases a motor, called a "gang" motor, will be used to drive a group of machines. The whole system of generator, wires, and motor really is a means of transmitting power.

The relative merits of individual motors versus gang motors depends on the conditions to be met. In general, individual motors cost more in the first place and require slightly more power for the operation of a given number of machines. This becomes conspicuously noticeable in the case of such machines as punch presses, a fact which was discussed briefly earlier in this chapter. On the other hand, no power at all need be consumed when a machine is not in use and the lighting of the shop is not interfered with by shafting and belts if gang motors are not utilized. Whenever the use of the machinery is intermittent, especially when the power is purchased from a central power station, individual motors are likely to be more satisfactory than gang motors; but when the operation of the machinery is constant, then economies can often be obtained by employing gang motors.

Other forms of power transmission.—In some instances, tools or machines are driven by compressed air as in the case of pneumatic hammers. It then becomes necessary to compress the air by means of compressors which are generally located in close proximity to the prime mover and the compressed air is then carried in pipes to the places where it is to be used. Great care must be taken to avoid leaks, for serious losses of power may easily be experienced in this fashion. Much the same thing can be said when steam is transmitted from the boilers for the use of steam hammers, or hydraulic transmission is used to supply hydraulic presses.

Conclusion.—As was pointed out in the opening paragraphs of this chapter, this whole problem is one of vital importance to the welfare of the company concerned. It has a special interest for the factory manager, for on its solution depends the solution of many other problems. It behooves the factory manager, therefore, to analyze his power needs with the utmost care and then carefully to weigh the various possibilities, not hesitating to call upon competent technical counsel.

References for Additional Reading.

Duncan, J. C., "Principles of Industrial Management," Chapter VII.

Fernald and Orrok, "Engineering of Power Plants," Chapters, X-XVI, XX-XXIV.

Jones, E. D., "The Administration of Industrial Enterprises," Chapter VI.

Lansburgh, R. H., "Industrial Management," Chapter XIII.

"Library of Factory Management," Vol. II, Chapters I-V.

Polakov, W. N., "Mastering Power Production."

CHAPTER VII

INTERNAL TRANSPORTATION EQUIPMENT

Purposes of this chapter.—

1. To study the problem of the selection of internal transportation equipment.
2. To see on what the needs are based.
3. To investigate means of meeting those needs.

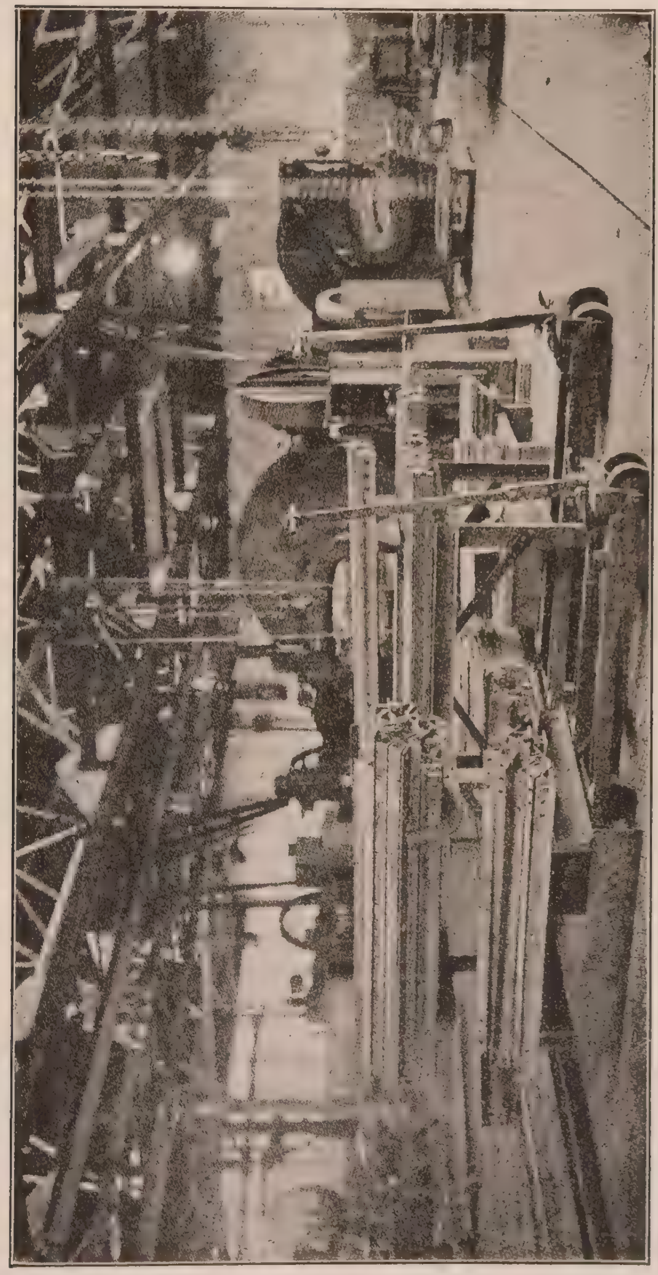
A problem which is faced by all manufacturing concerns is the selection of the means for moving the material from operation to operation from the time it is issued from the store room until it reaches the Shipping Department. In some cases the question is one of minor importance but in other instances it is one of the most difficult problems which the factory manager must solve. No value is added to the product by moving it a long distance during the course of its fabrication, and hence the factory should be arranged so as to reduce such movement to a minimum. From this point of view the layout of the factory will influence to a considerable extent the matter of transportation equipment. On the other hand, the possible means of moving materials will affect the layout of the plant and the construction of the buildings; for this reason the discussion of the transportation machinery is taken up before that of building construction. This case is simply another instance of the close interrelationship which exists among the problems of factory management. It is often necessary to answer one question at least tentatively in order to obtain a starting point for a study of some other.

The approach to the internal transportation equipment problem.—The approach which should be made to this problem is the same as that which has been advocated for the handling of the problems of the selection of machinery in general and of power production and transmission equipment in particular, namely, to investigate the needs first and then to analyze the existing means which may possibly be suitable for meeting those needs, designing new equipment only if none can be found which is suitable.

The material to be moved.—Obviously the first factor which demands attention in the effort to determine the internal transportation equipment needs is the material itself. Until its effect upon the transportation problem has been considered, there is no basis for an investigation of other factors. The weight of the materials is one of the points which must be investigated at the start. It is essential to determine how much weight is to be moved in the course of the day and the weight of the several units to be moved. The problem of transporting a ton of wood screws is very different from that of carrying a 2,000 pound casting from one place to another. The wood screws can be divided up into lots as small as may be convenient and a boy can easily move a ton of them a good many feet in the course of a day by making trips enough. The casting, on the other hand, must be moved all at once or not at all, and would require the services of a good many men to transport it even a few feet without the aid of equipment of some kind.

The quantity of material to be moved in the course of a day also has not a little bearing on this question. If only two or three packages of machine screws or nuts were to be delivered to the shop during the day, in all probability a boy with a tote-box would be the most convenient and efficient means of delivery. If the concern is making these articles and hence has occasion to move them by the ton, hand trucks, electrically driven trucks, or even cranes may well be used. If there are only a few castings of the size referred to to be moved perhaps two or three a week, it would not be worth while to install expensive equipment to handle them. If they were coming through regularly every day, then it would be necessary to provide crane service for their transportation.

The bulk of the product is also another factor which deserves consideration. In some cases, the weight is very much concentrated, as is the case with most metals, while in other instances the product is bulky in proportion to its weight. Automobile bodies are an illustration of this kind of thing. In the selection of transportation apparatus, concentrated

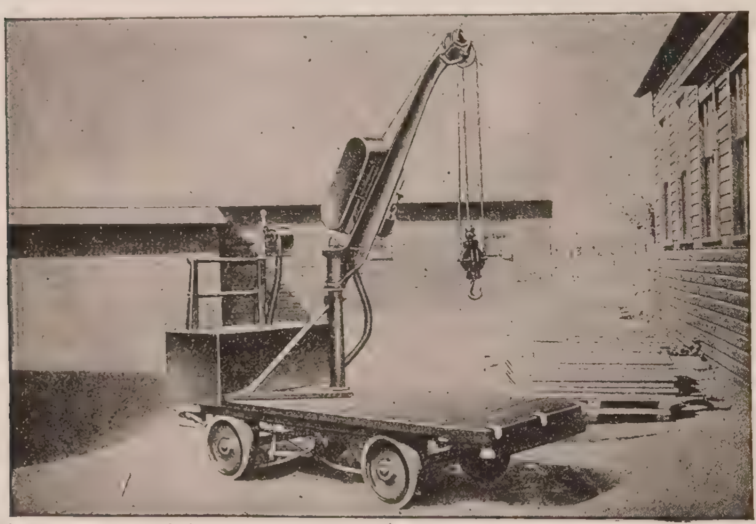


By Courtesy of Industrial Management and M. W. Potts.

Fig. 16.—Hand-operated Elevating Platform Truck.

weight or large bulk per unit will determine to a considerable extent the choice to be made.

The liability of the material to damage is often an important factor, for care must be exercised to make sure that goods which have been properly made are not injured while being moved around the factory. Some materials, like sheet steel or steel rods, can stand rough usage without danger of harm and no special measures need be taken to protect them. Others, like silk hats, delicate pieces of electrical apparatus, and glassware, must be adequately protected while in transit.



By Courtesy of General Electric Review and J. A. Jackson.

Fig. 17.—Motor-driven Truck Equipped with Crane.

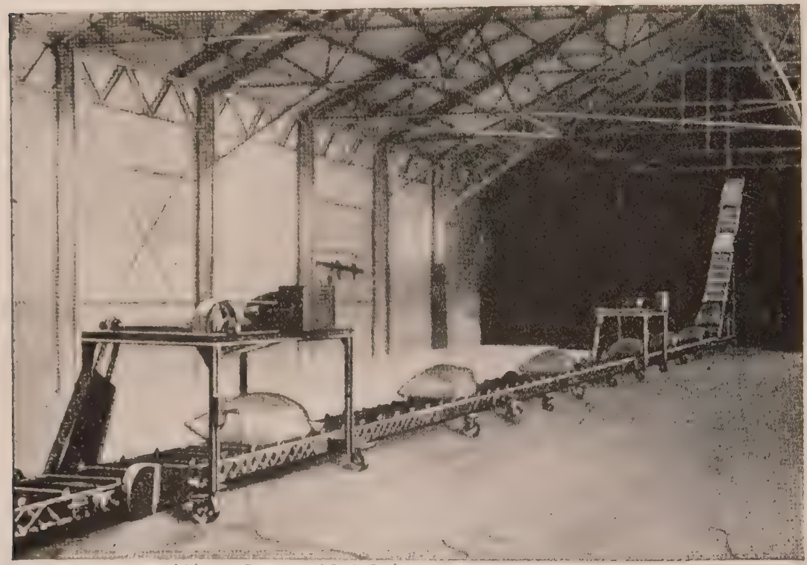
On the other hand, there are materials which, while not likely to be damaged themselves, may injure either persons or property during transportation and hence they must be properly guarded. Explosives are a conspicuous example of this kind of thing, but they are produced by so few factories that they do not offer a case of general interest. Acids, though much more inconspicuous, are likely to be far more of a problem, partly because in most cases their action is not so sudden or complete as that of explosives. The breaking of a carboy of acid, however, is likely to cause severe acid burns to any one who comes in contact with the fluid and most kinds of metals are attacked by acids which, when slopped over the floor, may eat out supports of machines, and, when spattered on the exposed portions of machinery, cause serious damage to vital parts. The upsetting of a can of glue from a truck while it is being moved about to fill glue pots may seriously interfere with the work of the shop for a much longer period than might seem possible.

White hot metal from a cupola is also dangerous to workers and work if control of the ladle containing it is not maintained at all times. In fact, the movement of iron and steel in the course of its manufacture at any time when it is hot is one of the most dangerous of tasks in a factory and one which is very frequently present because of extent of the industry.

The form which the material takes also has an influence on the choice of transportation equipment. Some materials are solids and are of such form that they need no containers while in transit. Large castings, sheets of steel, sheets of paper, etc., are examples of this kind of thing. Other goods, though solids, require containers of one kind or another. Screws, nuts, bolts, and almost all small parts must be placed in boxes or tote-pans before they can be conveniently moved, except in cases where it is possible to use an endless belt conveyor of some sort.

Many substances are fluids of one kind or another and this fact controls the ways in which they can best be transported. If they are to be handled in large quantities, then it is often possible to make use of pipe lines and pump them from place to place or let them flow by gravity. If only small quantities are to be moved at any one time, then it is necessary to use tanks, carboys, or some other form of container. It should be noted that not all fluids are liquids; some solids like grain are "fluids" also, in the true sense of the word, and can be treated as fluids when it is a question of their transportation.

The nature of the industry.—Having analyzed the various characteristics of the product from the point of view of their effect upon its transportation, it is next essential to consider the nature of the industry. The problem for a continuous process type of industry is very different in regard to internal transportation from what it is in the case of a jobbing concern. In the continuous process type of business, it is frequently possible to fix definite lines of transportation and install conveyors of one kind or another, of the general type shown in Figure 25, which are fixed to the building just as securely as is the machinery used in the actual fabrication of the product. In the continuous process industry, also, the necessity of making a correct choice of internal transportation equipment is far greater than in the jobbing type, for a small error in judgment which results in a repetition of many slight losses means a heavy loss in the long run.

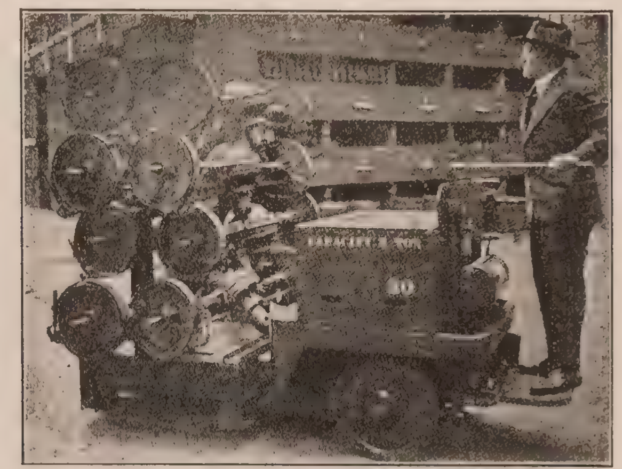


By Courtesy of General Electric Review and J. A. Jackson.

Fig. 18.—Motor-driven Horizontal Portable Conveyor.

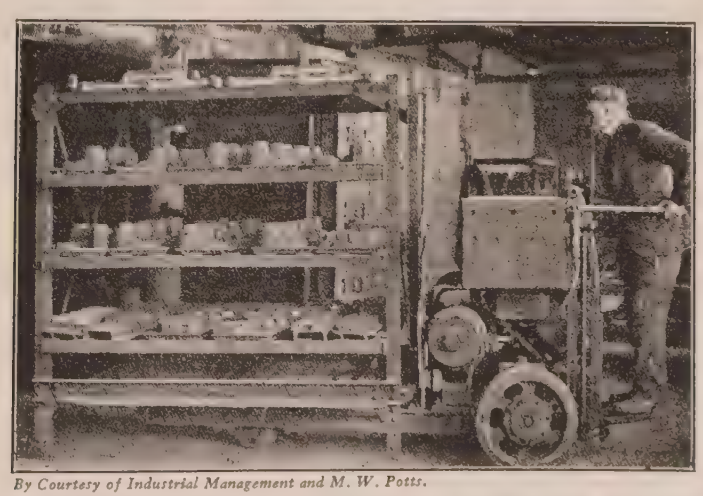
In some cases, also, the transportation machinery in this kind of industry may be integrated with the machines used in production. This is very well exemplified in some sections of the Ford factory. The casting of many small parts is controlled by the belt conveyor and the equipment is adapted to the needs which are based on the transportation device. As soon as the molds are made, they are placed on the belt and carried to the ladle where they are poured as they pass beneath it; they are then carried along till they are set, and next the outside sand is jarred off and they are put in tumbling barrels or removed for further processes.

In the jobbing type of industry, on the other hand, it is impossible to say in general terms just where the material is to go after it has been completed on any one machine. The variety of the sequences of operations is so great that it is quite impossible to lay down any fixed tracks for the material to follow as it proceeds through the factory. Of course each order should be routed through the shops, and so its path is known in advance; but there is no assurance that any other order will ever follow the same course. Hence it is necessary to employ some kind of internal transportation equipment which has



By Courtesy of Industrial Management and M. W. Potts.

Fig. 19.—Electric Storage Battery Truck with Special Truck.

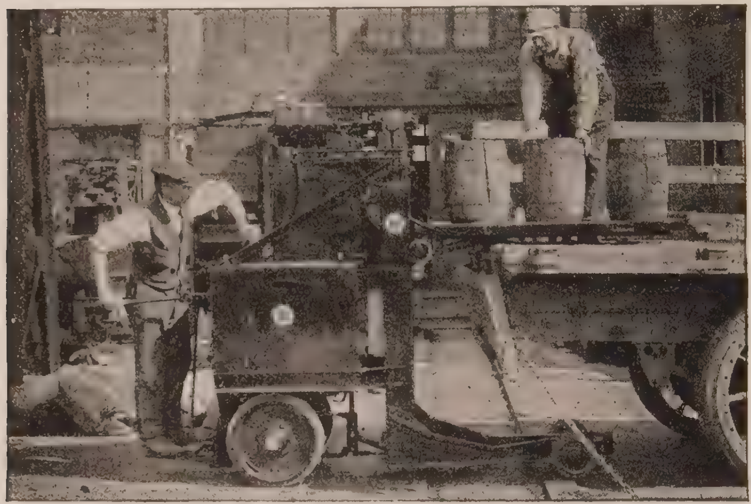


By Courtesy of Industrial Management and M. W. Potts.

Fig. 20.—Electric Storage Battery Truck with Special Platform.

great flexibility, usually trucks of one sort or another. The intermittent type of industry is likely to approach either the jobbing or the continuous types in respect to its internal transportation problem, depending upon the peculiarities of the local situation.

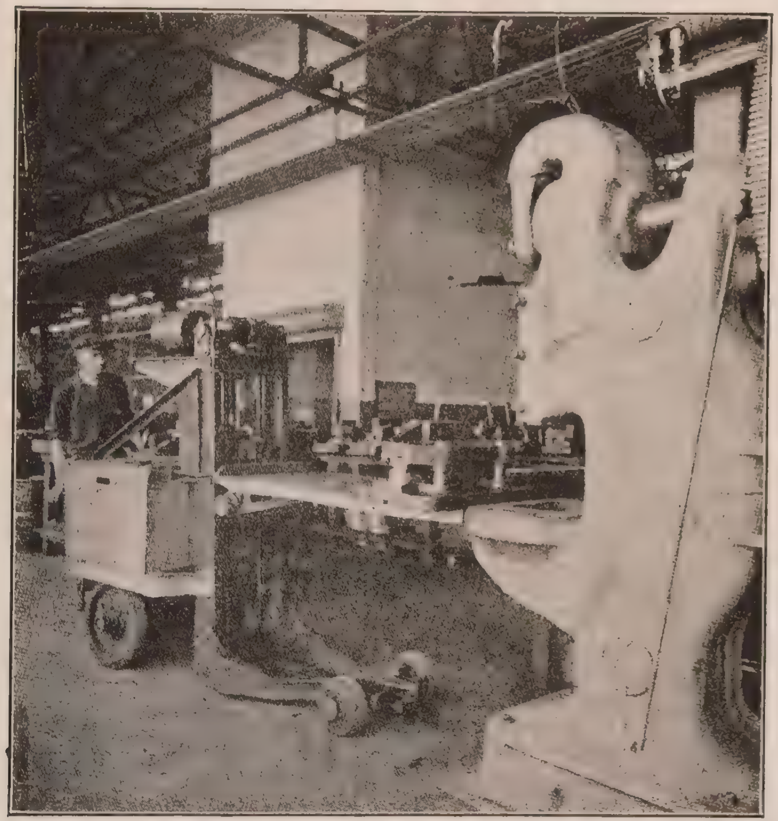
Available power.—The kind of internal transportation equipment to be selected depends in some measure also upon the kind of power available. In some few instances the operations in the factory may all be hand work, or the machines may be operated by foot-power. Hence no mechanical power is available and reliance must be placed on man-power to move the materials from production center to production center. Such cases are seldom found, for even the smallest shops have need of some power and buy it from a central power plant when it is not economical to produce it itself. Because the building is wired for electricity, however, it cannot be assumed that any power-operated internal transportation equipment can be used. Electric storage battery trucks, for example (see Figures 17, 19, 20, 21, 22, 23), must be charged with direct current at relatively low voltage, while most of the current supplied by central power stations is of the alternating variety. If there is need of a number of battery trucks in the factory,



By Courtesy of General Electric Review and F. T. Smith.

Fig. 21.—An Electric Battery Tiering Lifting Truck.

it probably will be economical to install a "rectifier" to convert the current from alternating to direct. If there is to be a relatively small demand for the use of such a truck, it may very well prove to be cheaper to use hand-power trucks.

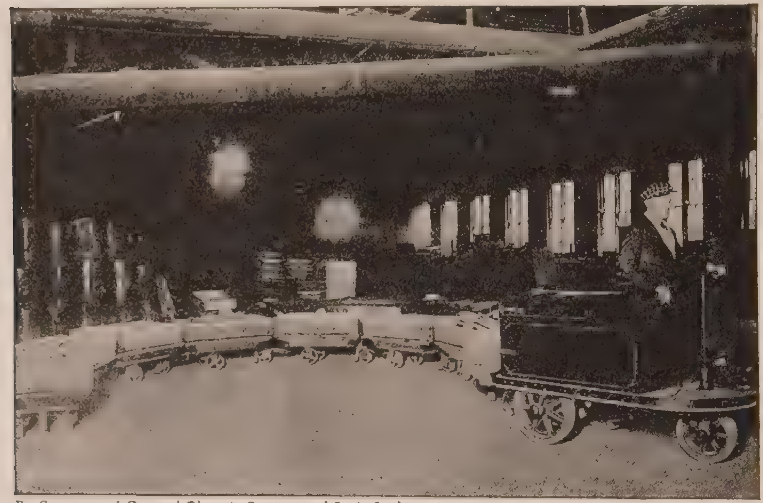


By Courtesy of Industrial Management and J. H. Van Deventer.

Fig. 22.—Electric Storage Truck Handling Heavy Tools.

Direct current is also required for many elevators and for tiering machines (Figure 27) which are operated directly from the current used in the shop and not by storage batteries. Cranes, both monorail (Figure 24) and overhead traveling (Figure 28), and all other equipment which is to be operated at varying speeds are much more easily controlled if direct current motors are employed. Of course, converters may be installed but this involves a cost of installation and an expense for operation which must not be overlooked in evaluating the desirability of this kind of equipment. Under some conditions pneumatic hoists may be desirable, but unless it is convenient to install a compressed air system in the plant and there is a sufficient demand to warrant an expenditure of this kind, then the lack of power in this form will eliminate all possibility of the use of this kind of hoist.

Building construction.—There are also certain modifying factors which must receive due consideration, many of them being details of building construction. The strength of the floors is a matter which must be analyzed in this connection. For example, if the building is already erected, the strength of the floors may limit the kind of truck to be selected. It might be desirable from some points of view to select a large truck capable of bearing a heavy load, but the lack of strength of the floors may prevent this otherwise economical selection.

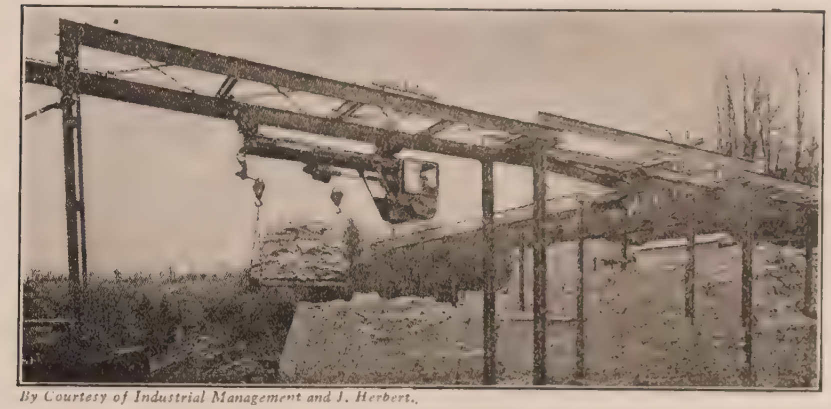


By Courtesy of General Electric Review and J. A. Jackson.

Fig. 23.—Electric Storage Battery Tractor and Trailers.

If the building is yet to be constructed, the selection of the internal transportation equipment will modify to some extent, perhaps, the design of the floors. It should be pointed out in this connection that the movement of material by trucks constitutes a shock load. Hence the factor of safety is always large.

The use of overhead traveling cranes (Figure 28) and monorail cranes (Figure 24) creates much the same kind of problem, for in these cases the weight must be borne not through the floors but by the frame-work of the building directly. If the use of cranes has not been envisaged when the building was constructed, it may be necessary to build a special frame to support them and their loads.

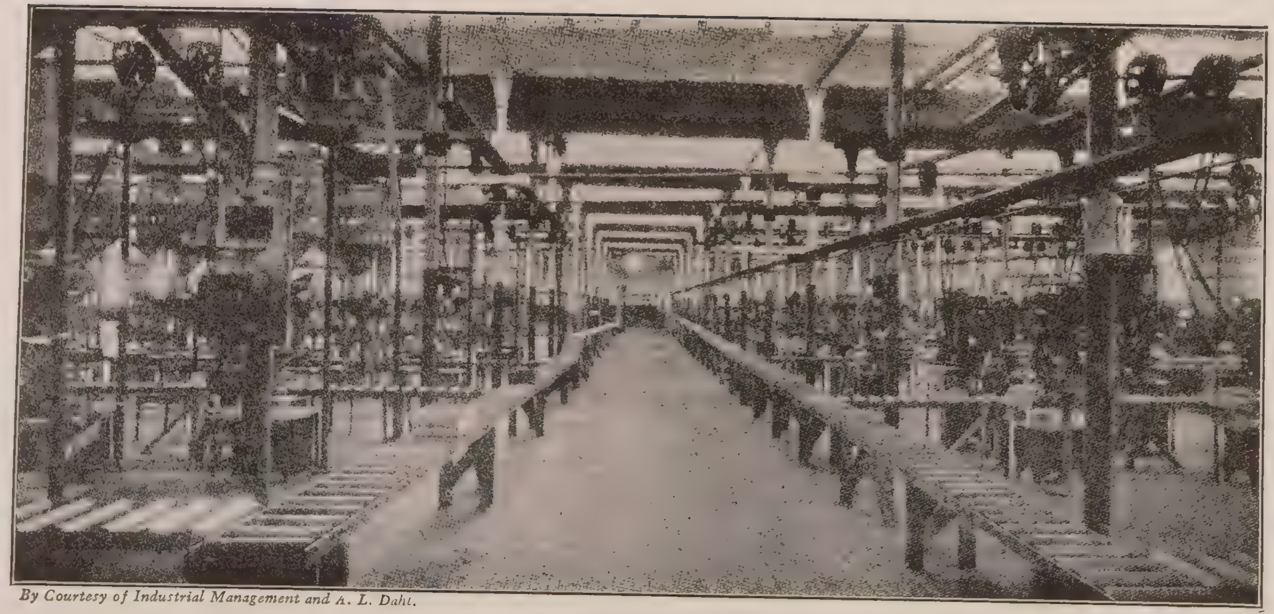


By Courtesy of Industrial Management and J. Herbert.

Fig. 24.—Monorail Crane.

The width of the doors and aisles is another factor which must receive consideration, for there must be room enough for a load to pass without danger either to itself or those around. If the doors are too small, the load may be upset or parts of it knocked off, and if the aisles are too narrow, there is always danger to the workmen at the machines which are adjacent to the aisles and to the machines themselves.

Fire hazards.—The fire hazards which are affected by the selection of internal transportation equipment must also be considered. The most conspicuous case of the increase in fire hazard on account of such equipment is that of elevators. This danger has been eliminated in large measure by inclosing all elevators in separate fire shafts with fire doors at each floor which are automatically kept closed except when the elevator is receiving or discharging freight at that point. A less frequent but more dangerous hazard, because complete protection against it has not yet been devised, is found in the use of gravity conveyors between floors. The opening between floors offers an excellent opportunity for fire to pass from floor to floor. Such openings must be closed by doors but in many cases



By Courtesy of Industrial Management and A. L. Dahl.

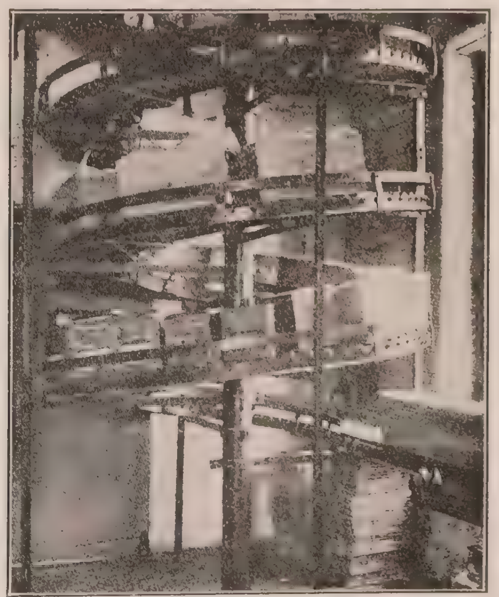
Fig. 25.—Horizontal Gravity Conveyors.

it is difficult to make them automatic in their action and hence much of their efficacy is lost. These illustrations are simply examples of the types of fire hazards encountered; there are many others which need to be considered.

Direction of movement.—In general, it is convenient to divide the transportation of material on the basis of the movement involved into three classes:

1. Vertical movement.
2. Horizontal movement.
3. Combination of horizontal and vertical movement.

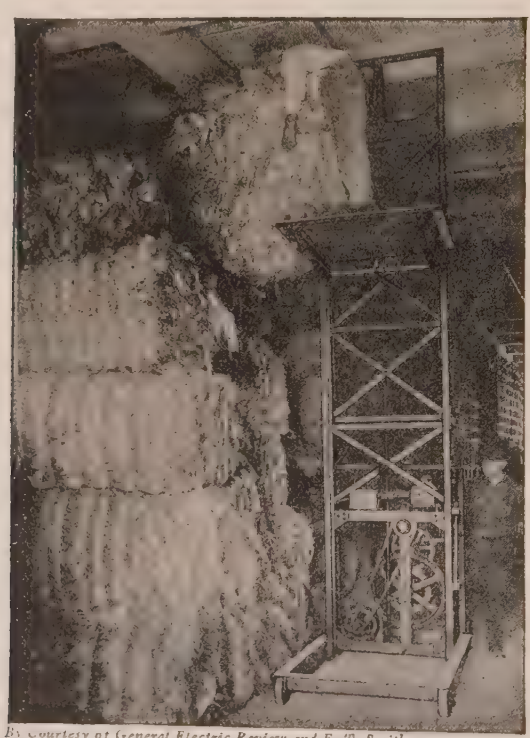
Vertical movement of material.—In moving materials vertically upward, it is necessary to work against gravity and this involves a much greater expenditure of power than is necessary to move them horizontally. After the goods have once been raised to the top floor of a multi-story building, it is often possible to use gravity for the rest of their transportation and reduce the cost of power in this way. There are certain limitations on the use of gravity, however, although its use is satisfactory in connection with the movement of many articles,



By Courtesy of Industrial Management and A. L. Dahl.

Fig. 26.—Gravity Chute.

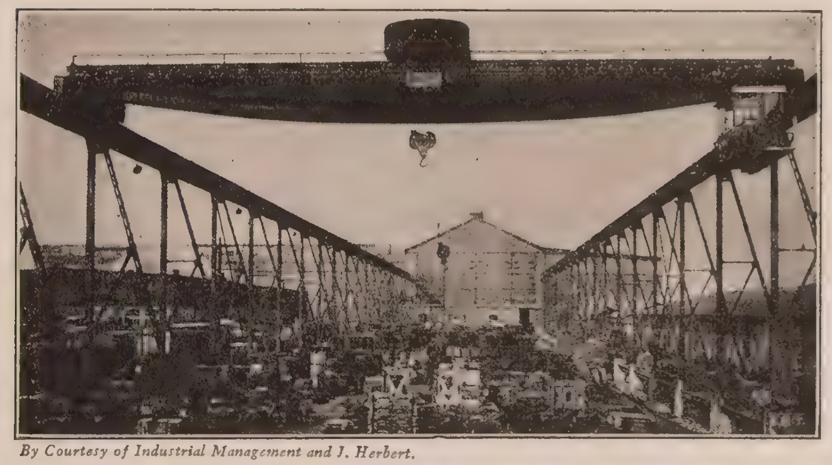
Articles which are delicate and easily injured cannot be moved in this fashion unless protected by containers, and this involves getting the containers back again to the starting point after they have been used. Liquids are also sometimes transported with difficulty by means of gravity conveyors. Modern equipment has reduced these possibilities of trouble to a minimum, however, and the number of products which can be moved in this fashion is constantly increasing. Very heavy articles are the ones which give the most trouble when the attempt is made to employ gravity to move them. It is easy enough to put a large unit weight in motion but once it has acquired momentum it is a problem to stop it. A thousand-pound casting is a much harder matter to control on a gravity conveyor than a thousand one-pound castings which can be sent down the chute one at a time.



By courtesy of General Electric Review and F. T. Smith.

Fig. 27.—Portable Electrically Driven Elevator.

Horizontal movement of material.—Horizontal movement of material presents other problems. To a considerable extent it is a question of the adequate support of the material during transit. If the course to be followed is definitely fixed, power driven conveyors may frequently be used. In some cases it is possible to replace the power driven apparatus with gravity equipment equipped with rollers. A slight inclination is often all that is necessary to keep the material moving for some distance. It can then be raised by hand or power and sent farther on its way. Sometimes these gravity conveyors are of the portable type. For moving heavy weights, cranes, both overhead traveling and monorail, are often employed. The overhead traveling type is designed to lift almost any weight which it is necessary to move around an industrial plant, even to complete locomotives.



By Courtesy of Industrial Management and J. Herbert.

Fig. 28.—Overhead Crane.

Combined vertical and horizontal movement.—For the combined vertical and horizontal movement of material, trucks and elevators are sometimes employed. The use of power driven trucks and ramps is becoming more frequent when this combination of movement is necessary. Overhead traveling cranes which move over a well can render this same type of service (Figures 30 and 32). In some cases, they are used to swing a truck and its load up several stories.

The distance which material is to be moved.—The distance which material is to be moved is still another factor which must be considered in analyzing the needs of internal transportation equipment. If the goods are to be transported only a short distance, simple gravity conveyors, either of the vertical or horizontal types, or hand propelled trucks, are usually all that are necessary unless the weights are large. For longer distances, however, power driven equipment becomes more necessary. The decision in regard to whether power or hand equipment is proper depends on a combination of weight and distance. As the weight increases, the distance within which hand power is economical decreases and the reverse holds true also. It should be remembered that every instant which transportation equipment is idle, it is non-productive and that the cost of hand power equipment is less per unit of idle time than is that of mechanically operated apparatus.

Hands vs. power transportation equipment.—There is a point, of course, where it is not economical to use any equipment at all, but there is little transportation in that class. It has been pointed out by Mr. R. H. McLain in "A Brief Directory of Material Handling Apparatus" [1] that the limit of human power unaided by mechanical devices is reached from the economic standpoint:

"1. Where three or four men are working together on one job for a couple of hours at a time, even though the work does not have to be done more than three or four times a week.

"2. Whenever a man has to lift anything from his feet to a point above his head.

"3. Whenever a man has to lift more than 50 lbs. from his feet to his shoulders.

"4. Whenever a man has to lift more than 100 lbs. from his feet to his waist.

"5. Whenever a man has to lift more than 150 lbs. from his feet to his knees.

"6. Whenever a man has to stand in one place steadily moving material for over 30 minutes.

"7. Whenever a man has to move material sidewise more than 6 feet, that is, two steps.

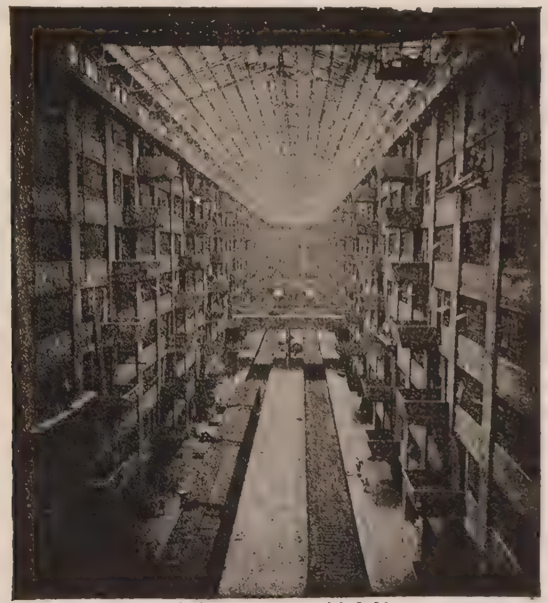
"8. Whenever a man or group of men, although moving around in a small radius, has to move more than 10 tons of material per hour."

---

[1] General Electric Review, Vol. XXIV, No. 4.

As soon as these limits are exceeded, it is necessary to consider the advisability of the introduction of mechanical equipment of one kind or another, operated either by hand or power.

Material handling equipment.—In recent years, there has been a considerable development in the variety of material-handling equipment which is available for the factory manager's selection. In fact, so many different kinds are to be purchased ready made that there is little need in most cases of considering the possibility of having any specially designed.



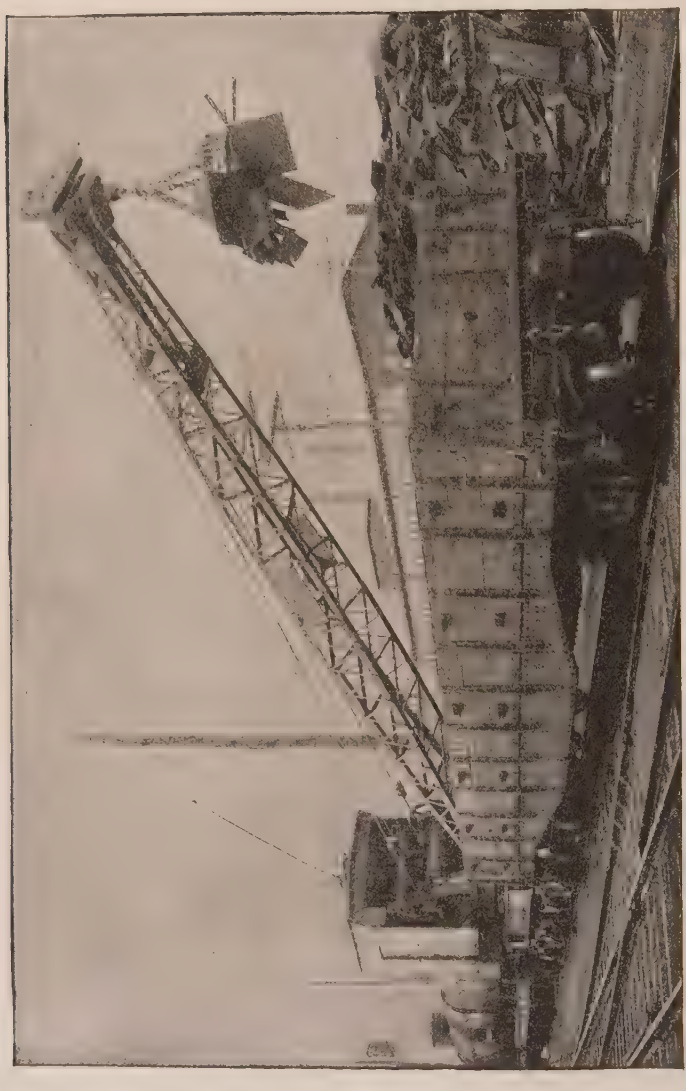
By Courtesy of General Electric Review and J. J. Matson.

Fig. 29.—Overhead Crane Used as an Elevator.

In the illustrations which accompany this chapter are shown a number of kinds of internal transportation equipment which are available for industrial use. The examples given present only a few of the possibilities.

In Figure 16 is shown a hand operated elevating platform truck of which there are a number of different makes now on the market. The platform is specially designed to meet the needs of the factory. Other types of platforms which might be used with the same truck are shown in Figures 20 and 22.

A motor-driven truck equipped with a crane is presented in Figure 17. The crane can be employed for loading other trucks as well as the one on which it is mounted.



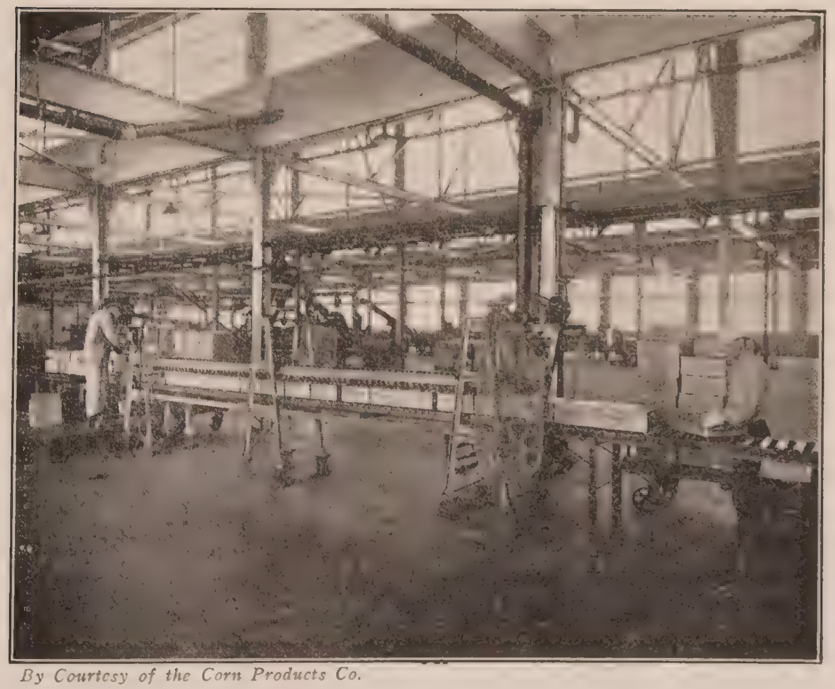
By Courtesy of General Electric Review.

Fig. 30.—Electro-magnetic Crane.

In Figure 20 is illustrated a motor driven horizontal portable conveyor. This device is especially useful in the intermittent type of factory where it is not possible to employ fixed conveyors.

In Figures 19 and 20 are shown two different kinds of electric motor driven storage battery trucks showing the different kinds of loads which can be carried. Both of these trucks are designed to pick up their loads on skids which can be deposited and the truck removed without disturbing the load.

A truck which is equipped so that it can lift its load several feet instead of a few inches only is illustrated in Figures 21 and 22. In Figure 22 it is shown in a job rather different from that which is ordinarily thought of as material-handling—that of delivering a heavy die to the punch press where it is to be used. There is considerable opportunity for saving in this kind of transportation which is often encountered among concerns using heavy tools.



By Courtesy of the Corn Products Co.

Fig. 31.—Roller Conveyor Used in Sealing Boxes.

In Figure 23 is illustrated an electric tractor with a train of trailers in tow. This type can be made very flexible and can be used in a relatively crowded factory if the trailers are arranged to steer with four wheels and so made to track each other. In some cases, also, it will be found desirable to replace the electric tractor with a gasoline tractor.

It should be noted that all of these trucks and tractors can be used for transporting goods from floor to floor if ramps are provided between floors, though the loads which may be carried under such conditions are less than those which it is possible to transport on a level.

In Figure 24 is illustrated a flexible device, known as a monorail crane, for the movement of materials. The single track can be arranged to go around curves and the cars can be switched from track to track. For loads which are too large for the tracks which have been shown up to 4 or 5 tons and, in some cases, more, the monorail is very efficient. It is also quite useful for carrying loads over ground which is not adapted to the use of trucks. It can run around the inside of a factory quite as well as outside.

One type of gravity conveyor which may be used for the horizontal transportation of goods is shown in Figure 25. Boxes or materials in the proper kinds of containers may be carried long distances for a slight vertical fall. Such conveyors, if arranged in sections, are also easily carried to other sections of the factory if needed.

A gravity chute for conveying materials from one floor to another is shown in Figure 26. It occupies only a small amount of space, it can be made to take large or small containers, or packages, and its slope can arrange so as to control the speed of descent to a considerable extent.

A portable elevator is illustrated in Figure 27. It is especially convenient in a storeroom where it is desirable to economize on floor space by piling up heavy packages.

In Figure 28 is shown an overhead traveling crane which can be used inside of a building quite as well as outside. The sizes and capacities vary from cranes capable of handling only two or three tons to powerful units which can lift a Pacific type of locomotive off the tracks. There are practically no weights around a factory which need to be moved which cannot be raised with this type of crane. The motion can be in any of the three dimensions within the limits of action of the crane.

A specialized use of this kind of crane is presented in Figure 29 where it is employed in place of an elevator. Materials are discharged on the unloading platform from the freight cars which are run directly into the building. The cranes which operate from the top of the inclosed areaway then take the goods and swing them up to any of the landing platforms which are shown at the sides.

When iron and steel are to be handled, an electro-magnetic crane like that shown in Figure 30 may be used. The magnet may be put on many types of cranes and not confined to the style shown here. Kegs of nails and bolts and other small iron and steel parts can be handled quite as well as the scrap and large parts shown in the illustration.

In Figure 31 a power-driven conveyor is illustrated. In this case the conveyor forms an integral part of a manufacturing process—the sealing of the containers. In many instances this type of conveyor is used in a similar fashion.

There is a great variety of equipment from which a choice of internal transportation equipment may be made, once a sound analysis of the transportation needs has been made.

References for Additional Reading.

"Library of Factory Management," Vol. II, Chapters XIII-XVII.
Price, G. M., "The Modern Factory," Chapter IV, Section IV.

CHAPTER VIII

PLANT LAYOUT

Purposes of this chapter.—

1. To study the ways to plan the layout of a factory.
2. To consider methods for recording those plans.

When the equipment of various kinds has been selected both as to kind and number of units of each, the next step is to plan the arrangement of the factory. The object to be sought is a layout which will promote low cost of production and this means, in general, a plan which will reduce the transportation of material to a minimum.

The value of an ideal factory layout.—In order to find the best possible layout, it is necessary to analyze the various factors which affect this problem. This is essential, whether the factory building is yet to be constructed or is already erected. If the building is not yet up, the ideal factory layout should form a basis for its design. In fact, the building should be built around the equipment as far as possible, modifications being made only as may be necessary to reduce the cost of construction where the gain due to the construction of the building to meet the ideal layout would be less than the increased cost. If the building is already up, then the ideal layout furnishes a goal to be arrived at in preparing the actual layout. It is seldom possible to realize the ideal; but it is always possible to approach it to a certain extent, and, in any event, a better arrangement of equipment will result than if the ideal plan has not been prepared as a starting point.

Factors controlling the layout.—The task of preparing such an ideal layout is not an easy one, for it involves a consideration of many factors, not only those which have been determined more or less definitely, such as the kind and quantity of machinery which is to be used, the means for the production and transmission of power, the probable quantity of production and hence the probable amount of material which is to be stored, but also factors which have been only tentatively decided upon, such as the internal transportation equipment, and still other factors which depend largely on the layout itself, but which, nevertheless, have a certain effect upon it like the type of building construction to be used. It will usually be found that a good many tentative layout plans will be needed before it is possible to reach an arrangement which will give proper consideration to all the various factors involved.

An analysis of manufacturing processes.—The starting point for the layout of the factory is a thorough analysis of the processes to be carried on therein. Such an analysis should have been made, of course, in connection with the selection of equipment, but at this time, it should be revised and extended. The simplest type of industry from the standpoint of plant layout is the continuous type. This is true whether it is of the analytical or synthetic (assembly) variety and whether the processes themselves are simple or complex, easy or difficult to control. The reason for this is that once the routing, as the sequence of the processes or operations is called, has been determined, the theoretically ideal plant layout follows immediately therefrom. The same thing is true in most cases for the intermittent type of industry, which is more likely in this respect to approach the continuous process type than the jobbing type.

This problem in the jobbing type of industry is more difficult. In the first place, it is possible to forecast only in a general way the kind of work which is to be done. This condition is the very essence of this type of industry. In the second place, it is impossible to analyze definitely the processes necessary to produce an article until the article is known. It might seem from this that there is no possibility of laying out the jobbing type of factory scientifically, and that the best thing to do is simply to let it grow and put in a new machine when it is needed wherever the space for it seems to be most available.

Such, however, is not the case; a great deal can be done in connection with a jobbing industry to lay out the plant in such a way as to promote ease and low cost of manufacture. If a careful study is made of the kind of work in which the company expects to specialize, it will be found in most cases that certain tendencies exist for one sort of operation to precede another. In most cases, for example, it will be discovered that drilling operations in a machine shop come after certain turning operations on the lathes or planing operations on the planer or shaper. The reason for this is evident, for it is necessary to have relatively accurate surfaces from which to measure in order to center correctly the holes which are to be drilled. Under such circumstances it will be desirable to locate the drills further away from the storeroom and nearer to the assembly department than the lathes or planers.

Another more obvious illustration may be found when a jobbing machine shop has a foundry run in connection with it. Here it is evident that the departments should be arranged so that the pattern shop, pattern stores, core department, foundry, casting, stores, and the several divisions of the machine shop come in the order named. This holds true regardless of the kind of work which is being turned out.

This careful analysis of the processes involved in the production of the goods in a definite sequence of operations is discussed later in connection with the establishment of manufacturing standards. There it is studied under the head of routing work through the factory. It should also be pointed out that the standard routing of the work through a continuous process type of factory is, essentially, the plant layout in so far as the direct processes of manufacture are concerned, and that this routing in such a factory is "frozen," as it were, by the actual placement of the machinery.

The importance of a satisfactory layout.—For a number of reasons it is of vital importance to make sure that the plant layout is made properly. One of these reasons is the same as that pointed out in connection with the selection of machinery —that the decision once made and the equipment installed, the effects, for good or bad, will be felt indefinitely. Small losses will be repeated many times over and small gains will accumulate. In many cases, it is almost impossible to make a change once the building is constructed, for when it is built in a special way to meet particular needs, it is frequently very difficult to alter it without, in a large measure, rebuilding the whole edifice. Even if it is mechanically possible to rearrange the layout, it is a costly and difficult process, involving serious delays in the production of merchandise. It must not be forgotten that not only must machinery be moved when the plant layout is being altered, but it is also necessary to change the line shafting and counter-shafting, if there is any, and the wiring for motors and often for lights as well. In many cases partitions must be knocked out and others erected and sometimes an elevator shaft relocated.

Plant layout in a continuous process type of factory.—It has been pointed out that in the continuous process type of industry, the layout should follow the routing of the work from operation to operation. This is theoretically correct and offers a good basis for the practical arrangement of the equipment. It often happens, however, that modifications are necessary to meet the exigencies of the particular situations, which result in a departure from the straight-line course of production. Take, for example, a sequence of processes in which is one requiring special equipment and quite possibly a special building for that equipment. The heat treatment of metal parts is an illustration of this kind of thing. If it is necessary to locate such a process in a separate structure, and especially if the parts worked upon must come to this process several times in the course of its fabrication, then it is often impossible to avoid this break in the continuous straight-line advance of production.

The desirability of avoiding such departures from the ideal layout has resulted in the improvement of many of these processes to the point where it is now possible to include them in the regular plant layout. This is particularly true in the case just mentioned, of the heat treatment of metals. Modern heat treating furnaces for small parts have been developed to the point where they can be put in the ordinary machine shop without any particular inconvenience.

Another case of where the forward movement of materials in the continuous process type of factory must sometimes be interrupted is found in the small concern where the output is not large. Here it may well happen that a particular machine can be used for performing two distinct operations separated by one or more other operations. If there is work enough on each operation to keep one machine busy on each operation all the time, then there is no problem, for one can be placed where it is needed in the sequence of operations for each operation in question. If, however, there is only enough work of both kinds of operation to keep a single machine busy, then, in most cases, it is unwise to have two units and have each of them idle a large part of the time. Hence it frequently becomes necessary to "back-track" the material to the machine for a second operation after one operation has already been performed.

In laying out the plant, especially the continuous process type, it is desirable to keep constantly in mind the possibility of making use of gravity as a means of transportation of the materials. It will generally be found that where it is possible to move materials in this way, it is cheaper than it is to move them horizontally, unless gravity is used in the horizontal movement also. A careful study of this phase of the problem will often show that seemingly impossible arrangements are practical and economical. A foundry is ordinarily thought of as a department where heavy materials, heavy equipment, and heavy products are the rule and that, in consequence, work must be carried on on the ground floor, usually in a single-story building. A company whose product was of metal and many small castings found it quite practicable to place its foundry on the top floor of a five-story building. From here the castings were carried by gravity to the next floor where the machining was begun and so on to the other departments until they reached the Assembly Department on the first floor. Finally they reached the Finished Stock and Shipping Department.

In connection with the use of gravity, it should be noted that the Receiving Department of the same concern was on the first floor, but that the Stores Department—or rather that section of it in which the raw material was stored — was located in the basement to which point the material was easily transported by gravity from the Receiving Department.

As a general rule, it will be found that it is most convenient in the continuous process type of industry to group the operations according to the article worked upon rather than according to the kind of machine used or the operation performed. This arrangement, of course, is quite in accord with the principle of having the work proceed as nearly in a straight line as possible. It has some advantages from the organization point of view, as was suggested in Chapter III, in that it permits the men and the foremen to become thoroughly familiar with the product which they are making, and hence promotes efficiency of operation.

This arrangement also promotes the easy use of automatic conveyors, either power or gravity operated. The workman can take a part from the conveyor as it moves past him and replace it when he has completed his operation on it. This is not possible, of course, when it is difficult to balance the equipment. It is quite possible, however, to arrange the machinery so that several workers can feed on to the same conveyor or take their work from it at such a rate as to keep only one worker busy at some other production center.

Plant layout in the jobbing type of industry.—In the jobbing type of industry, it is seldom possible to make use of conveyors, as the various jobs rarely follow the same track through the shops. Each order or section of an order should have a definite route which it will follow, but these routes are usually different for each order. Hence, it is necessary to rely on the individual movement of the work from place to place by means of trucks or other equipment capable of traveling over a variable course.

It will also be found in the jobbing type of industry that under many circumstances it is wise to group like production centers together—lathes in one place, for example, drills in another, planers in a third, etc. It has already been pointed out that a careful study of the production to be handled will ordinarily aid greatly in locating such groups in such a way as to keep the amount of transportation at a minimum. One of the principal gains from this arrangement is the familiarity with the machinery under their control which both workmen and foremen gain. This familiarity promotes the speed and satisfactory accomplishment of the tasks which are assigned. This is especially important in the case of the jobbing type of industry where it is not possible to prepare operation standards in any great detail and much more must be left to the intelligence and resourcefulness of the men at the machines than is necessary in the continuous process type of industry.

The interrelationship of departments. — While most of the discussion so far has been conducted on the basis of the layout of a particular department, allusions at several places have hinted at a larger phase of the problem—the proper layout of the departments in relation to each other. An illustration of this problem was given in the case of the factory with the foundry on the top floor and the storeroom in the basement. Even more transportation of materials to no purpose may result from the lack of coördination in the physical layout of the departments than from the unsatisfactory arrangement of machines without a department. This is especially true in regard to the storeroom and its relation to the shops. It should be in a position to supply them quickly with the materials which they need and often, also, to receive from them completed parts and sub-assemblies which will be wanted later to make up the salable merchandise. Hence it is often wise to sub-divide the storeroom, physically, into a number of sections.

Future expansion.—This problem is complicated by the fact that, not only must the needs of the present moment be considered, but also the possibility of future expansion. Failure to think of the future when present arrangements are being made frequently results in heavy expenditures later, which should have been avoided. In solving this problem various shapes of plant layout may be employed like those indicated in Figure 32, where the solid lines indicate the first construction and the dotted lines possible ways of expansion.

From the diagrams shown it is perfectly evident that, if the land is available, a building may be expanded in various ways to meet the needs of a business. If the supply of land is limited, then the ideal layout of the plant is often hampered, and, if all the land is occupied at the start, the only chance of expansion is up into the air. Upward expansion is often economical if the original plans of the building provide for it. Otherwise, it is a very costly undertaking.

Graphic methods of recording a plant layout.—In working out the arrangement of a factory, it is usually desirable to make use of the graphic means of representing the location of departments and machinery. The first plans may be simply rough, freehand sketches not drawn to scale like those shown in Figure 34. The next step is to draw the outlines of the departments to scale and to show the location of the machines therein by little slips of paper or board (Figure 35) cut to scale also, which may be placed so as to show the location of the machines in the department. If the drawings are mounted

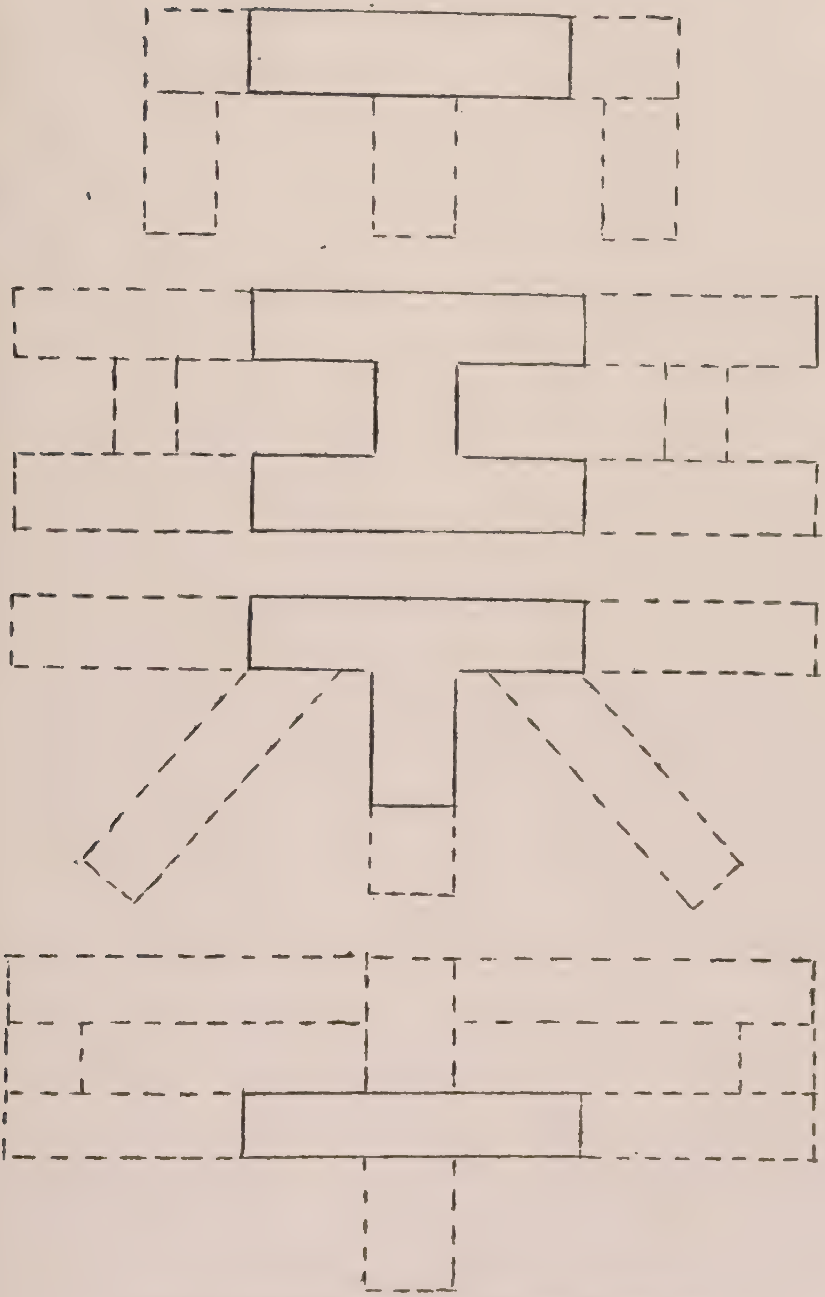


Fig. 32.—Building Layouts with View to Expansion.

on a drawing board, the slips of paper, or "templates" of the machines, as they are usually called, can be held in place by thumb tacks and shifted to form various combinations until the best one is found.

The next step is to have rough floor plans of the proposed

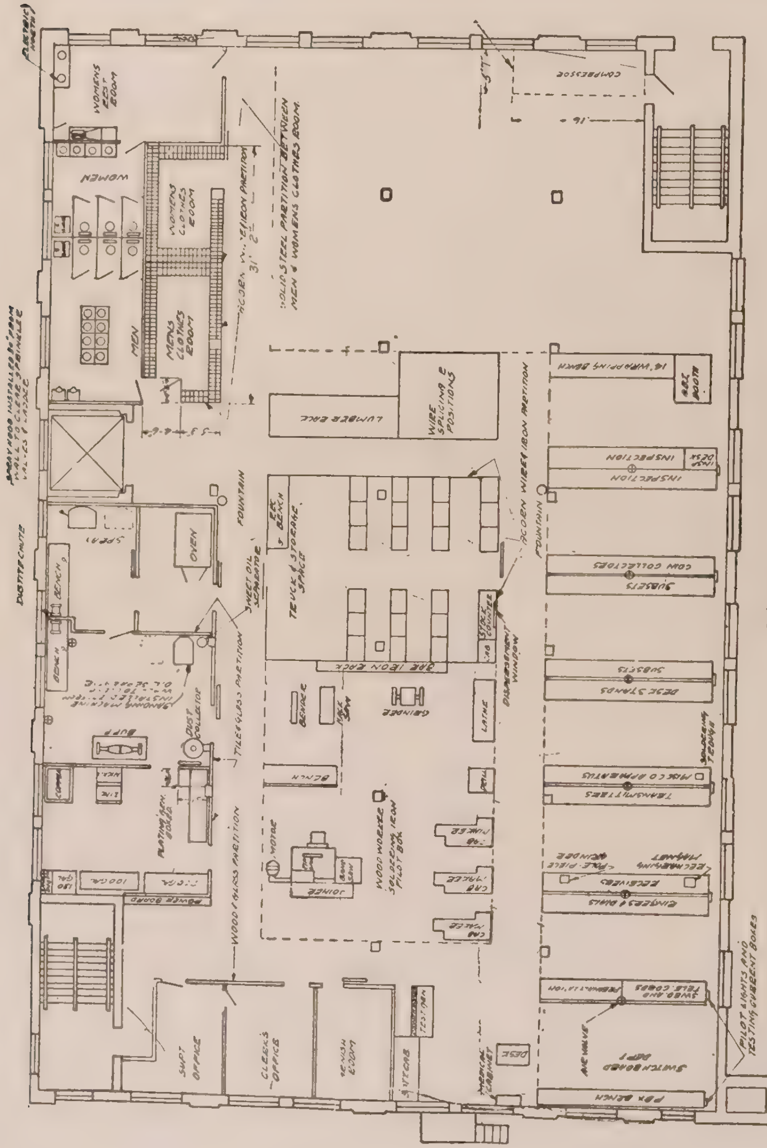
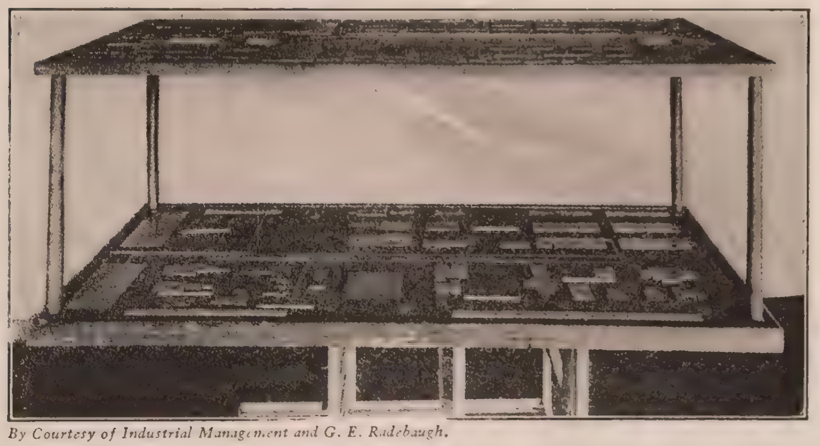


Fig. 34.—Floor Plan.

By Courtesy of Elmer Moon.

building prepared by the architect, and with these it is possible to study the layout in connection with the construction details —the position of machines in relation to windows, power conduits, etc. It may be found that the existing plan calls for the location of a machine on a spot where it is necessary to have a post, or in such a position that the post cuts off the light from an operation which must be done with great accuracy. Under such circumstances a readjustment is necessary. It may be found also that risers for the sprinkler system may interfere with the original plans or that other unforeseen obstructions will upset the plans. In some cases the building plans can be modified; in other cases the layout must be changed. Finally, the finished floor plans, illustrated in Figure 34 should be completed.



By Courtesy of Industrial Management and G. E. Radebaugh.

Fig. 35.—Skeleton of Building with Templates Showing Plant Layout.

It is often desirable to be able to study the relationship existing between departments or machinery on two different floors. One of the best ways to do this is to prepare a skeleton of the building (see Figure 35) and represent the machines by templates previously described. In other cases, an isometric sketch like that shown in Figure 36 will be the most desirable way of presenting the possibilities.

By using these and other graphic means of showing the plant layout it should be possible to study the problem in great detail before the construction of the building is begun. In spite of all the efforts which may be made to plan in advance, it will usually be found necessary to make a number of minor changes, but, without plans carefully made beforehand, the confusion during construction is likely to be serious, and the losses in the subsequent operation of the plant are usually costly.

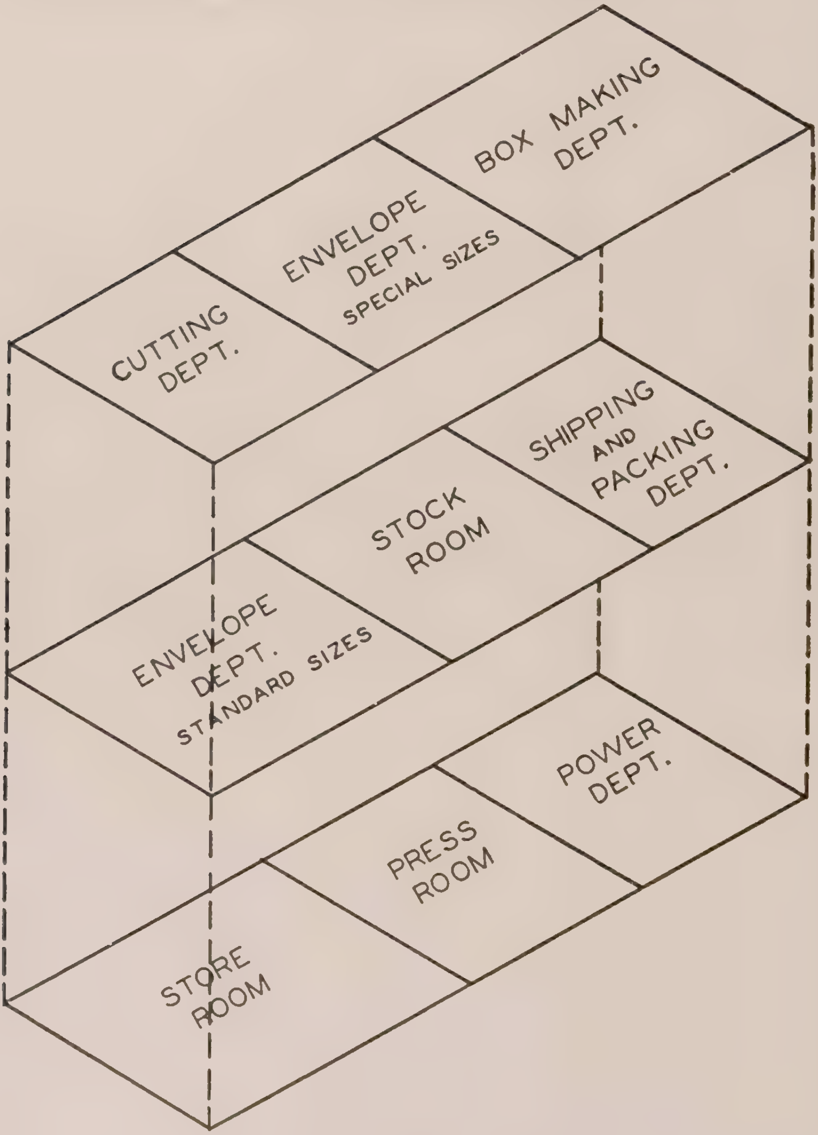

BOX MAKING DEPT.
ENVELOPE DEPT. SPECIAL SIZES
CUTTING DEPT.
SHIPPING AND PACKING DEPT.
STOCK ROOM
ENVELOPE DEPT. STANDARD SIZES
POWER DEPT.
PRESS ROOM
STORE ROOM

Fig. 36.—Isometric Sketch of Plant Layout.

References for Additional Reading.

Basset and Heywood, "Production Engineering and Cost Keeping," Chapter VI.

Day, C., "Industrial Plants," Chapters I-IV, VIII.

Jones, E. D., "The Administration of Industrial Enterprises," Chapter IV.

Lansburgh, R. H., "Industrial Management," Chapter X.

CHAPTER IX

THE CONSTRUCTION OF A FACTORY BUILDING

Purposes of this chapter.—

1. To investigate the problems to be solved in the construction of a factory building.
2. To study ways of solving these problems.

The building is a master tool.—The factory should be considered the master tool with which the factory manager is equipped. If it is not properly designed and constructed for its work the whole manufacturing function will suffer. Because of the fact that a building is so permanent a tool, any changes in it are sure to be costly, and hence the utmost care should be exercised to make the right choice at the start. To be most satisfactory the building should be constructed as far as possible around the equipment, slight modifications being made when necessary with a view to economy of construction. All too frequently in the past, however, the building has been designed and erected before the machinery which it is to house has been selected or its layout planned. Such a procedure has usually resulted in losses which are continuing, losses due directly to the nature of the building and indirectly to difficulty in the control of factory operations.

The method of approach to the building problem.—As in the case of the problems which have been discussed in the preceding chapters of this section, the proper starting point for a solution of the present problem is an analysis of the needs which are to be met and their effect upon the structural details, and next a selection from the available means, or from those which may be developed, of the elements which, when properly put together, will meet the needs which have been revealed.

To a considerable extent, the needs which must be met should have been revealed already in the investigations which were made for the purpose of the selection of the machinery and other equipment, and for the preparation of the plant layout. It is essential, however, to go over these details again to see that factors, which might not have had special significance in connection with the other problems, are not overlooked.

The effect of the product on building construction.—The product and the materials of which it is composed should be reviewed once more to see what effect they may have upon the type of construction. Acetic acid, it was pointed out, attacks concrete, which, therefore, should not be used in any exposed position in the construction of a factory in which that substance will be produced.

Textile mills must be so constructed that a constant degree of temperature and humidity can be maintained therein. Equipment can be provided to do this, but care must be taken in the northern part of the country to provide walls for the building of a kind which will not result in heavy condensation thereon in the winter months.

The weight of the product is still another factor which must be considered, for it represents a load which the floors must bear and for which they must be constructed. Any weight on the floors is transmitted to the frame-work which, in turn, must be designed to meet the stresses set up.

The effect of equipment on the design of the building.—The equipment which is to be used also has an important influence on the construction of the building. It is obvious that its weight will have substantially the same kind of effect as the weight of the material and must be added thereto in calculating the stresses involved. It must not be overlooked, however, that machinery in certain cases has a characteristic which affects the design of the building much more than the weight involved. There are few machines which do not have moving parts and these parts always cause a certain amount of vibration. If the motion is rotary and the parts are carefully balanced, the vibration is slight and may, perhaps, have little significance. If the motion is reciprocating, and especially if the parts in movement are heavy, the vibration is often large and its effect may be a serious problem. In some instances, in fact, it may be necessary to place such machinery on the first floor where it can rest on solid concrete foundations separate from those on which the building itself is placed.

The limitations placed on the building by its location.— In laying out the plant, due consideration should be given to the shape of the land. It must not be overlooked, however, that in addition to its effect on the layout of the factory, and through it on the building, the shape of the land may often raise some problems in connection with the design of the building directly. For example, the location of the necessary posts so as to provide adequate strength and, at the same time, not encumber the floor area, may be difficult to decide upon.

The surrounding buildings, especially if they belong to some other company and are immediately adjacent, as is usually the case in a city, raise some questions of fire hazards. In spite of the great advance which has been made in recent years in the development of sound fire regulations and their adequate enforcement, the individual owner cannot afford not to investigate such a matter when he is constructing a new building, nor to provide himself with adequate protection. As a corollary to this, he should analyze the need of protecting his plant and his neighbor's from any possible fire hazards which may arise in connection with his product or processes.

The site of the building should, of course, have been carefully analyzed long before the question of building construction is reached. It is largely a matter of plant location, and, as such, is affected by many factors outside the range of the manufacturing function of the business. There is one element in regard to the site, however, which has special importance in connection with the erection of the building. The geology of the land needs to be studied carefully. If the land is solid rock, it may be a little difficult to construct the foundations because of the amount of blasting which may be necessary. But the foundations, if they are themselves sufficiently strong, can be depended upon to sustain almost any weight which may be placed upon them. If the soil is soft and muddy, however, it is often necessary to sink a great deal of piling, and even then there may be danger that the load which will be placed on the foundations will be too much for them. One well-known concern learned by bitter experience the lesson that the cost of foundations must be carefully calculated in advance and be predicated on investigations by geologists and engineers. This firm had to pay more than four times what it expected the entire building would cost simply for the foundations, and all of this expense was due to the nature of the land which might have been ascertained in advance.

There is still another phase of the land question which is important in wet localities. The basement floor must be so constructed as to be capable of resisting both the weight which is put upon it from within, and the pressure which the water in the soil may exert upon it from without. In short, whenever the soil is not firm and capable of sustaining heavy loads, the problem of the construction of the building is greatly increased thereby.

The height of the building.—One of the first questions which must be answered in regard to the building is its height, both immediate and future. To a large extent the first part of the question has been answered in the preparation of the plant layout, and to a certain degree the second part, also. It is important to decide definitely in regard to this matter before the foundations are begun if the building is to be multi-story and if there is any possibility that it will be extended upward. It is very difficult, if not impossible, to enlarge foundations so that they will carry extra loads after they are once in, and it is only a little less difficult to strengthen the frame so that additional floors may be added. If the possibility of expansion upward is seen at the start, it is quite possible to lay foundations and erect a structure to which vertical extensions can be made quite easily and with a minimum of expense.

Fire hazards.—When making a decision as to the height of a building the matter of fire hazard must be considered. In most cases the multi-story building presents greater hazard in this respect than does a single-story building, due to the fact that fire tends to go up rather than to one side unless driven by a strong wind. This does not mean that the hazard from fire in a multi-story building cannot be kept low, if the building is of fire-proof construction and care is taken to have no openings between floors, except in special towers, or to have those openings, when they cannot be avoided as in the case of gravity chutes, well guarded. The fire hazard is not absent in a single-story building, especially where a large area is included under a single room. In such cases it is desirable to divide the floor space by means of brick fire walls with the openings closed by means of fire-doors.

Fire-doors, whether they are between two rooms on a floor or between a room and a stairway or an elevator, should be made of fire-proof material and constructed to close automatically. In case the doorway is used extensively for trucking, and hence much time would be lost if it were kept closed and had to be opened by hand each time a truck passed through, it can be tied open by means of a piece of string which is weak enough so that it can be easily broken by a vigorous pull. It should be the duty of two trustworthy employees who work near the door to see that the string is broken and the door closed at the first indication of fire anywhere in the building. The construction of such doors varies, for there are several ways of making them fire-proof. One design calls for two sheets of metal with an air space between, the whole being closed at top, bottom, and ends. Another lighter door, intended for daily use when there is much passing through its doorway, employs much thinner sheets of steel which are mounted on wood. The wood, when the door is attacked by fire, is charred and frequently burned, but the plates hold. The substitution of wood for metal decreases the weight and makes it easier to handle the door.

Single story or multi-story buildings.—Both single story and multi-story buildings have their advantages. The single story building has the advantage of better light and ventilation, since both can be secured through the roof. This is of prime importance in a foundry or other department where there is much dust and many fumes, or where the work requires great precision, and hence the good lighting. If the soil is reasonably solid, there is almost no limit to the weight which may be placed on the floor of a single story building nor does vibration usually cause any serious difficulty. In the multi-story building there are distinct limits which must be placed on both weight and vibration. The relative fire hazards and the means of transportation of these two types of buildings have already been discussed. The relative cheapness of construction can hardly be compared, except with a definite case in hand, as so many factors enter into the factor of cheapness of construction.

Building foundations.—It is desirable to give some attention to the foundations. A few words were said in regard to this problem in connection with geology of the location; they do not need to be repeated here. In the northern part of the country the foundations need to go below the frost line, and in most cases, it will be found necessary to carry that portion of the foundation still further on which most of the weight of the building and its contents rests. In the majority of modern factory buildings the weight is not carried on the walls, but on the framework, and hence the weight-bearing portion of the foundation consists largely of a series of pillars. Wherever there is heavy machinery, especially any which may cause marked vibration, foundations entirely separate and distinct from those on which the building rests are built. At the present time the tendency is decidedly to use reinforced concrete as foundation material, though brick and stone may also be used to advantage when their cost is low enough to compare favorably with that of concrete.

The foundations for a single story building cost less per running foot of foundation than do the foundations for a multi-story building. The entire foundation cost may be greater, however, as there is a much larger floor area per linear foot of foundation in the case of the multi-story building than for the single-story building. The relative cost of the two depends largely on the kind of soil and on the load which the foundations must bear. If the soil bears heavy loads easily—if it consists of good clay, for example—it is possible to put in foundations at a small cost per linear foot, and under such conditions the foundations for a single story building would be cheaper than for a multi-story building. Of course, this is only one element in deciding which type of building to use.

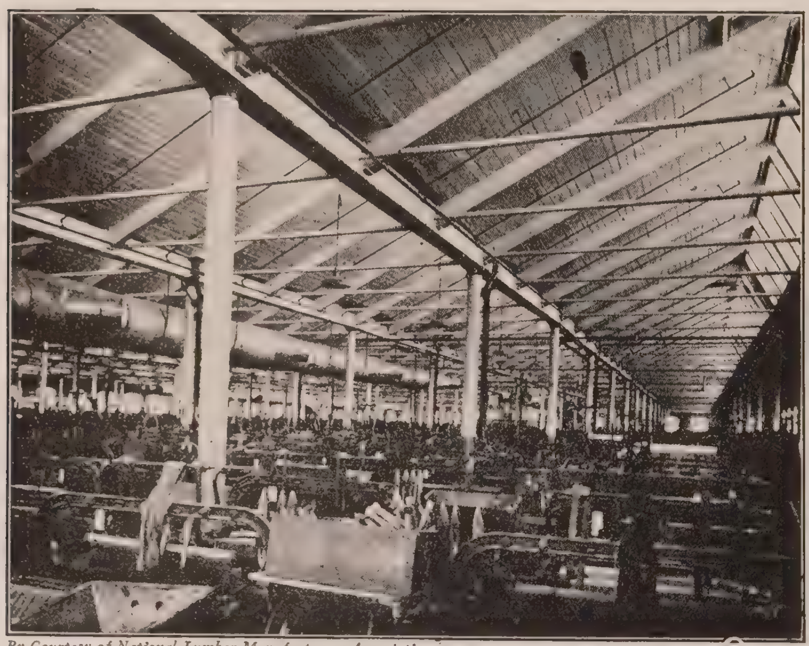
Type of building construction.—The kind of construction or kind of material out of which the building is to be erected deserves careful consideration. In general, the types of building from this standpoint may be divided into four groups:

1. Frame construction.
2. Slow-burning or "mill" construction.
3. Steel frame construction.
4. Reinforced concrete construction.

These four groups tend to merge into each other, and in particular cases it is often difficult to decide in just which class a certain building belongs. It is not of any vital importance to answer such a question, but it is helpful to create these four groups as a basis for further discussion.

Frame construction.—The first of these four groups is the least important of all and includes, principally, sheds and temporary buildings. Such structures are made almost entirely of wood and no special attention is given to making them fireproof. Hence, as a rule, they are highly combustible, and because of the increasing cost of lumber they are being used less and less, being replaced to a large extent by the simpler types of steel frame "fabricated" buildings, or steel frame buildings covered with sheet metal.

Slow-burning or "mill" type of construction.—The second type of building, the slow-burning or "mill" type of construction (see Figures 37 and 38), is also of wood. While built largely of wood with brick walls, it is far more fireproof in its construction than the layman might think and has rendered very important service to manufacturers. The fire-resisting character is based on the fact that it is difficult for fire to burn directly through a plank, it always burns around the edges and so consumes it gradually, and also on the fact that,

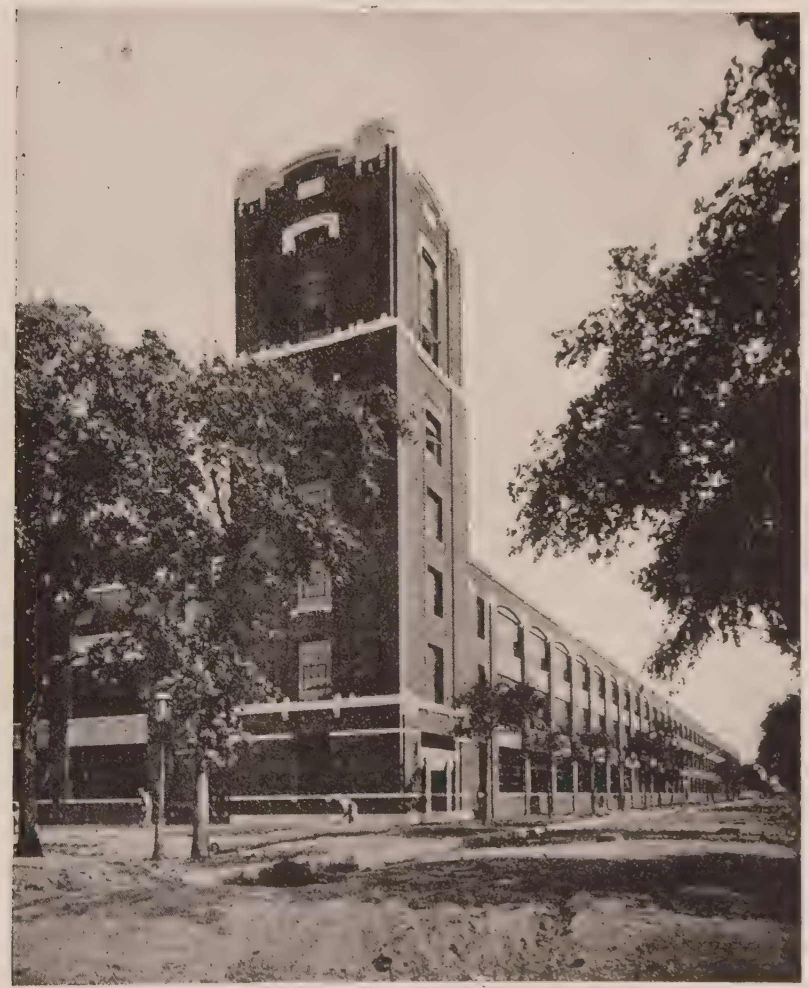


By Courtesy of National Lumber Manufacturers Association.

Fig. 37.—Interior—Mill Construction Building.

once the outside of a plank is charred, the carbon covering so made serves to protect to a certain extent the unburned wood beneath.

In this type of construction the uprights and beams are of solid timber, not light joists, braced so as to give the needed strength to resist the loads put upon them, but providing also an excellent place for fire to catch and burn. The floors, also, are constructed of two layers of heavy plank laid at an angle to



By Courtesy of National Lumber Manufacturers Association.

Fig. 38.—Exterior—Mill Construction Building.

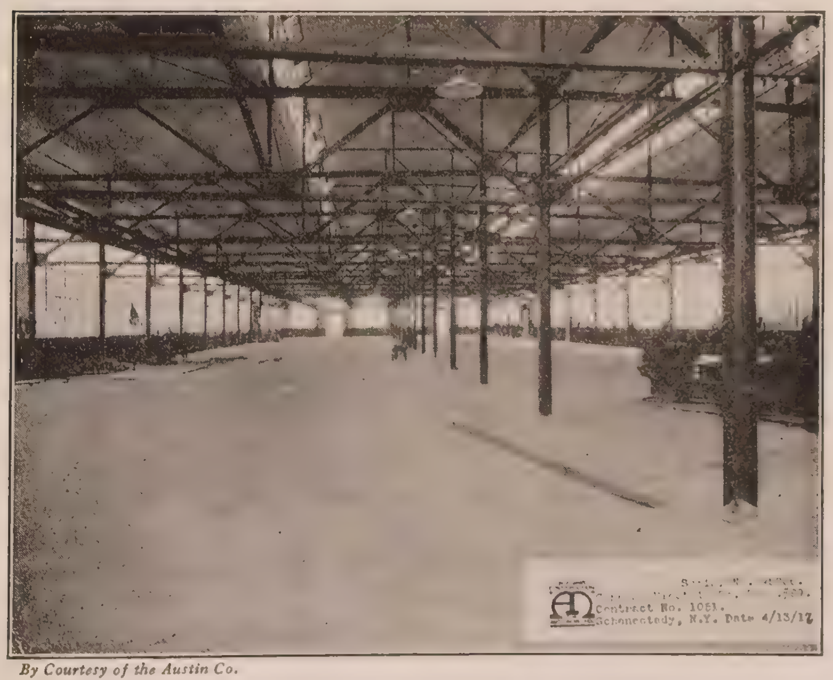
each other, and with no air space between them. The stairways, elevators, and power shafts are all carried in outside brick towers so that they can be shut off completely from the various floors. The walls are usually of brick, and in recent years of tile or some other fire-resisting material. Division walls are made of brick, and are often constructed to extend out from the sides of the building for a distance of several feet so as to prevent flames from leaping from window to window. The roof is always flat, for pitched roofs provide peaks into which a fire gets and is hard to reach and extinguish. In short, every effort is made to prevent a fire getting outside the particular part of the building in which it starts and where the chances are the best for extinguishing it.

Automatic sprinklers.—A large part of the security from devastation by fire in this type of building results from another factor, however—the automatic sprinkler. This device consists of series of pipes running across the ceilings of the various stories of the building with a sprinkler head every so many feet. The pipes are filled with water which should be supplied from a reserve tank located above the building and usually supported by a separate framework. If a fire starts anywhere it raises the temperature; as a result, the plug in the nearest sprinkler head melts, for it is made of fusible material which will melt when a certain predetermined temperature is reached, and the water is automatically sprayed in a fine mist upon the fire below, which, in most cases, is at once put out. As soon as the water starts flowing in the pipes, a fire alarm is automatically turned in, and the fire department of the factory or city or both should arrive at once to supplement the work of the sprinkler, if necessary, or to shut off the water and pump out the department if the flames have already been extinguished.

This method of fighting industrial fire hazards was first developed in connection with the type of building under discussion, but its use has been extended to all kinds of buildings. When installed in a well designed, properly constructed reinforced concrete building, a structure results which is substantially absolutely safe from internal fire hazard, unless the processes carried on therein are extra-hazardous.

Until lumber became so high, this type of building was comparatively inexpensive to construct; now it is much more costly. It is easy to erect, however, and is reasonably durable. It is not difficult to alter it and the relocation of shafting and motors can be accomplished without difficulty. On the other hand, it transmits vibration easily, cannot be built to support heavy weights, except at disproportionate increase in cost, its load carrying capacity is reduced with age, and, when it is old, the cost of repairs is heavy.

Steel frame type of construction.—The steel frame type of building (see Figure 39) is the third class of building referred to previously. In this type of construction the frame is made of exposed steel members, round posts, I-beams, T-beams, Z-beams, etc. The frame carries the entire weight of the building in most cases, including the walls which become nothing but curtains to keep out the weather. The floors are sometimes of plank, sometimes of steel-frame covered with some other kind of material, rarely of reinforced concrete. As in the slow-burning type of building, the building is usually



By Courtesy of the Austin Co.

Fig. 39.—Steel Frame Type of Construction.

divided into sections by means of brick fire walls, and is protected by a sprinkler system. The connections between floors are made so far as possible through outside towers.

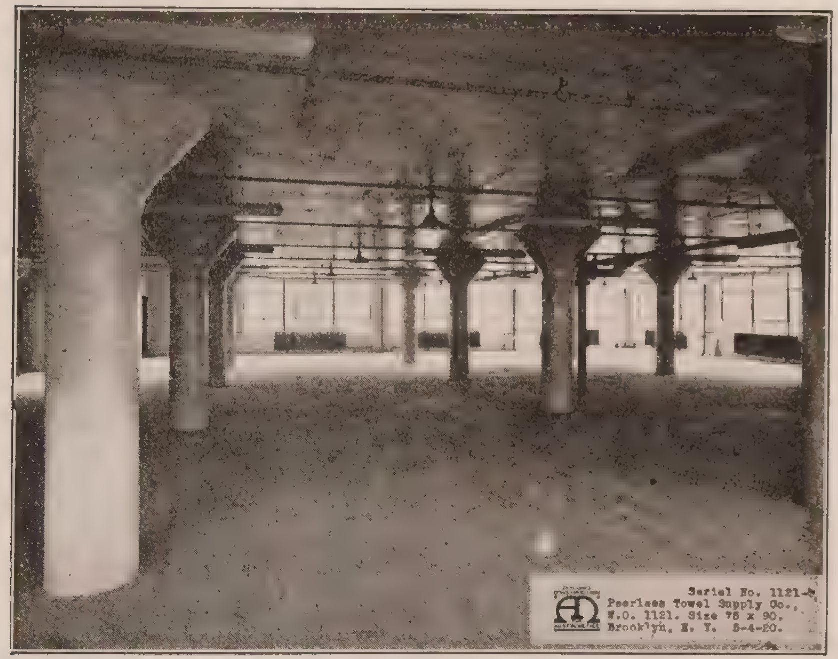
It would seem at first glance as though this type of construction would be much more fire-proof than the slow-burning type. Although this is a relatively good fire-resisting type of building, it is no better in this respect, and in many cases is not as good as the slow-burning type. The reason for this is that, although steel will not actually burn until its temperature is raised to a very high point, its capacity for resistance to loads is much decreased if it is heated even a little. Hence, though it will not burn, the exposed steel frame will buckle and allow the upper floors and roof to come down. The equipment which is not destroyed by fire is usually so damaged that it has only scrap value and must be thrown out. The fall of one part of the building often drags down other parts which are sometimes out of immediate danger from the fire, and so the resulting losses are likely to be large.

Many of the fabricated buildings which are used so extensively as temporary structures, and which have been developed to the point where many permanent buildings are constructed in this way, are made in this fashion.

This type of building has a relatively low first cost, is easily altered, and transmission equipment can be located and changed without difficulty. Its maintenance cost is a little high, it transmits vibrations easily, and its depreciation, while not very rapid, is an important factor. It has a wide variety of uses, and with the increasing cost of lumber will probably replace the slow burning type, except near the forest regions.

Reinforced concrete construction.—The most modern kind of industrial building construction is reinforced concrete. (See Figure 40.) In this type the weight of the upper floors, roof, and walls are carried largely by the frame as before. The uprights are of steel encased in cement, reinforced by steel rods; the floors are ordinarily of reinforced concrete; and the walls of the same material or of brick or tile. Here the fire hazard is very much reduced because the steel is no longer exposed but covered up by the cement, and the cement itself carries a part of the load.

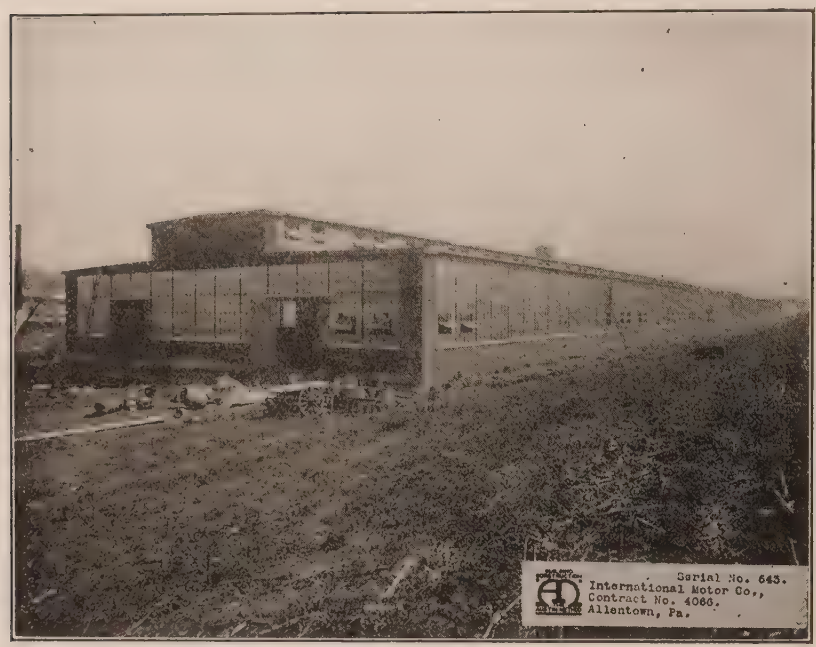
This type of building, especially when equipped with automatic sprinklers, is practically indestructible by fire. It is rigid and resists vibrations. Its rate of depreciation is low and the cost of repairs small. It is vermin proof and is not damaged by water and steam. It is still relatively costly to erect though much less so in proportion than a few years ago; it is difficult to alter, and transmission equipment is not easily installed in it. Without any question the reinforced concrete building is the coming type for industrial purposes.



By Courtesy of the Austin Co.

Fig. 40.—Reinforced Concrete Construction.

The walls of the building.—The walls of the building have been mentioned several times, but they deserve a little further consideration. Years ago, the walls were used to carry a large part of the weight of the structure and its contents. This meant that the amount of wall space available for windows was limited. As the use of steel became more general, an ever increasing amount of the weight has been placed upon the frame until now, as was pointed out in a previous paragraph, the walls are, to a large extent, simply a means of protection against the elements. Under such conditions the wall area is used principally for window space, and in the extreme cases the entire side of the building may be made of glass. (See Figure 41.)

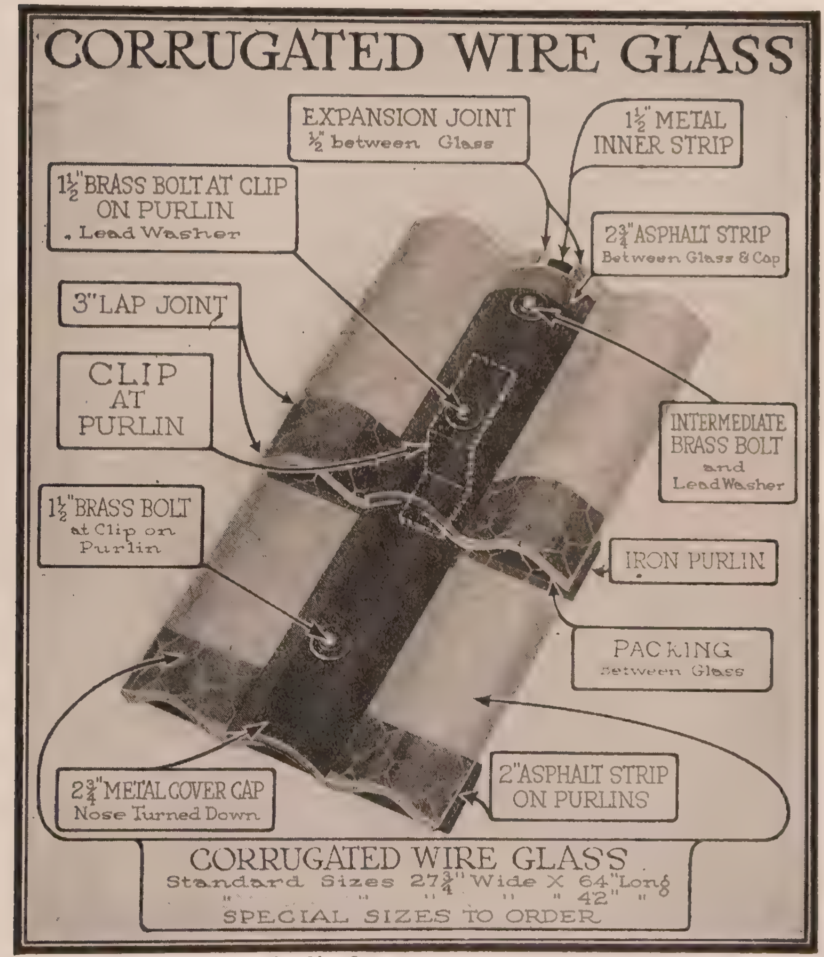


By Courtesy of the Austin Co.

Fig. 41.—Building with Glass Walls and Monitor Roof.

The use of plain glass is not satisfactory under many circumstances, however, because it allows a great deal of light to fall near the windows, and at the same time creates shadows and semi-darkness in the interior of the building. One way of preventing this is to make the building sufficiently narrow so that the sunlight can reach the center from both sides. The glare may be prevented by means of awnings or shades. A better way, however, is to use a specially designed type of glass which is constructed so as to turn the rays of light in toward the center of the building. In some cases the glass is prismatic and in other cases it is waved. There are a number of kinds which are quite satisfactory. If this glass is used in any place where there is a fire hazard it is ordinarily made so as to include a mesh of wire and is called wire-glass. (See Figure 42.)

The wire does not interfere to any extent with the passage of the light. It will not keep the glass from cracking when exposed to an intense heat, but it does keep the cracked glass together, and so enables it to prevent the passage of the fire.


CORRUGATED WIRE GLASS
EXPANSION JOINT ½" between Glass
1½" METAL INNER STRIP
1½" BRASS BOLT AT CLIP ON PURLIN, Lead Washer
2¾" ASPHALT STRIP Between Glass & Cap
3" LAP JOINT
CLIP AT PURLIN
INTERMEDIATE BRASS BOLT and Lead Washer
1½" BRASS BOLT at Clip on Purlin
IRON PURLIN
PACKING between Glass
2¾" METAL COVER CAP Nose Turned Down
2" ASPHALT STRIP ON PURLINS
CORRUGATED WIRE GLASS
Standard Sizes 27¾" Wide X 64" Long
" " " " 42" "
SPECIAL SIZES TO ORDER

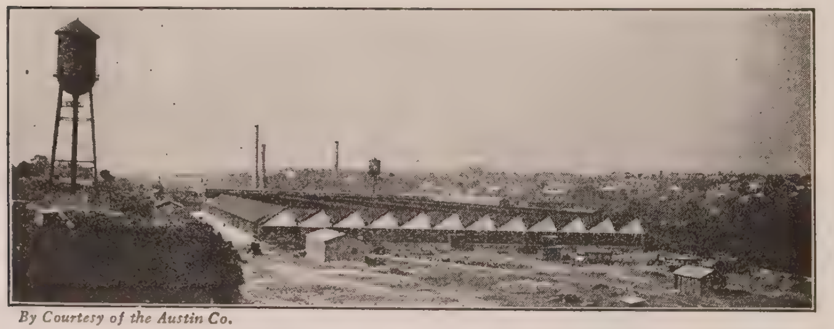
By Courtesy of the Pennsylvania Wire Glass Co.

Fig. 42.—Corrugated Wire Glass.

In most cases provision is made for natural ventilation by making a part of the window space so that it can be opened. The portion of the wall which is not of glass is usually of concrete, tile, brick, or some other fire resisting material.

In some cases the construction of the wall presents one of the most difficult problems in the design of the building. In the textile industry, for example, as has been mentioned before, it is essential to maintain in most of the departments a constant degree of temperature and a constant and relatively high degree of humidity. A single thickness of wall, which is satisfactory for most industrial buildings, does not meet the demands of this situation, especially in the northern part of the country, for in the winter there would be heavy condensation on the exterior walls. To obviate this trouble, walls were constructed double and this meant practically doubling the cost of this part of the building. In recent years, however, the use of hollow building tile has made possible the construction of single walls which, because of the insulating effect of the air spaces in the tile, are able to meet the needs of this kind of industry.

Roofs of factory buildings.—The best way to get light is not from the side of the building but from above. Except for the top floor of the multi-story structure, light through the roof is not possible in this type of building. The top floor of a multi-story building and the whole of a single-story building can be lighted from above, however, and hence it becomes necessary to consider the roof in this connection.



By Courtesy of the Austin Co.

Fig. 43.—Building with Saw-tooth Roof.

The roofs of industrial plants are generally flat, except in the case noted below, because of the reduction of the fire hazard. Peaked roofs give the fire a chance to work where it is hard to reach and they do not allow easy access by firemen on the outside. A flat roof of opaque material does not aid in the solution of the lighting problem, however. If the roof were made flat and of glass, the glare would be serious and the difficulty of making it water tight great. In most cases the difficulty is met by means of what is called a "saw-tooth" roof. (See Figure 43.) The glass is placed in the short side which is always turned toward the north, or as near the north as is possible. In this way the direct rays of the sunlight are avoided and with them the bothersome shadows. The arrangement provides natural lighting as nearly ideal as it is possible to obtain.

The glass side of the tooth can usually be opened to obtain natural ventilation, which is supplemented by that from windows at the side. In foundries and departments where there are noxious fumes and dust, this ventilation is often not sufficient and to meet such situations the monitor type of roof has been developed. (See Figure 41.) In this type of roof, the windows on both sides of the peak can be opened, and frequently they are arranged in two vertical rows. With an arrangement of this kind, it is possible to set the windows, no matter what direction the wind may have, in such a way as to secure good ventilation. While the lighting is not as good as with the saw-tooth roof, it is quite acceptable, nevertheless, especially for the type of work which requires this kind of roof for ventilation.

Fundamentally, the building is the master tool of the factory manager, and, as such, it deserves its proportionate share of his care and attention. Properly constructed to meet the demands which are to be placed upon it, it is a constant source of service and satisfaction; improperly designed and poorly erected, it is certain to result in steady loss.

References for Additional Reading.

Duncan, J. C., "The Principles of Industrial Management," Chapters X-XI.

Jones, E. D., "The Administration of Industrial Enterprises," Chapter V.

Lansburgh, R. H., "Industrial Management," Chapters XI-XII.

"Library of Factory Management," Vol. I, Chapters I, V, VI, VIII-XV, XVII, XVIII.

CHAPTER X

MAINTENANCE AND UPKEEP OF PLANT

Purposes of this chapter.—

1. To consider the reasons for plant maintenance.
2. To study the problems which are involved.
3. To investigate methods for solving those problems.

Once the buildings are erected and the necessary equipment installed, it becomes necessary to consider their maintenance and upkeep. For the first few weeks or even for the first few months the problems to be faced are usually not difficult, but even from the start, maintenance and upkeep must receive attention, for under this head comes the daily cleaning and removing of waste materials which are necessary to keep a factory in operating condition.

Reasons for the importance of maintenance.—There are many reasons for the importance of the maintenance of the factory in proper condition, most of which may be included—directly or indirectly—under the head of "economy." In the first place, it is less expensive to make minor repairs before the need becomes so serious that it requires extensive overhauling. The same thing holds in regard to the daily sweeping and cleaning; it costs less to have it done regularly than it does to allow dirt to accumulate and have it removed in large quantities. Of course, there is need of common sense in applying such a rule. In a food factory it may be worth while to provide for the immediate elimination, continuously or several times a day, of any dust or other substance which might damage the food. In a machine shop when certain machines are removing large quantities of metal, it may be well to have the chip pans emptied twice a day before they overflow, and the floors swept every other day, while in the storeroom a weekly sweeping may be quite sufficient. The principal point is that the cleaning should be done regularly and frequently so that the cost may be kept at a minimum.

Adequate upkeep means lowered depreciation.—In the second place the systematic upkeep of the plant means that its life will be prolonged and hence that its rate of depreciation and the consequent depreciation charges will be less. The importance of this phase of the question is particularly great for those concerns where the investment in fixed assets is heavy, for a slight reduction in the rate of depreciation in such cases will often decrease the operating expenses materially. If the machinery is subject to hard usage, proper maintenance also has a decided effect on the depreciation charges.

Satisfactory maintenance reduces capital investment.—The amount which it is necessary to invest in buildings and equipment, particularly the latter, may be lowered if their upkeep receives adequate attention. One reason for the necessity of spare machines lies in the fact that at all times some machinery is likely to be down for repairs. If breakdowns can be anticipated and prevented, the result is very much the same as though additional equipment were provided and at the same time the costs attendant upon the possession of more machinery are avoided.

Maintenance and manufacturing standards.—Another important reason for keeping equipment in first-class condition is that it is almost, if not quite, impossible to set operation standards, and extremely difficult to maintain them, if the standards of first class condition of the machinery are not enforced. If the operating efficiency of any machine is impaired because it is not in a proper state of repair, it is not possible to determine the speed at which it should be operated or the output which should be expected from it. Even if operation standards are once set, if the condition of the machinery is not maintained, there is sure to be difficulty about the continuance of the operation standards which have been established.

The question of standards very naturally leads to the subject of the control of current production. If standards of operation cannot be maintained, there is little chance of living up to the schedules for production in the shop which have been set up, for such schedules are predicated on the operation standards. Proper maintenance of equipment, therefore, is absolutely essential if the control of current production is to be effective. It is necessary, of course, that all the machinery be in a state of repair if schedules are not to be seriously interrupted. But a single machine, or group of machines, which is constantly breaking down may very well spoil the schedules for the entire shop by failing to provide parts or materials for subsequent operations. This is another illustration of the fact that a chain is only as strong as its weakest link.

Proper maintenance reduces accidents.—The number of accidents to the workers may be materially reduced by the adequate maintenance of the machines which they use. The loss from such accidents is felt by the company not only in the compensation which they are obliged to pay or in the liability insurance premiums which they must assume, but also in the shutting down of the machine after it has been repaired, because of the absence of the workman or the reduced output which a new man produces. In some cases, the loss of a "key" man may seriously hamper the operation of the entire shop.

Losses due to idle equipment.—It has been noted that inadequate maintenance results in various ways in the shutting down of the machines and the consequent idleness and nonproductiveness of both men and equipment. The loss due to idle men as long as they remain on the payroll is obvious and needs no discussion here. It may be stopped by laying the men off, but the risk is run of crippling the operation of the factory by being unable to get them back when they are wanted.

Administration of production.—The loss from idle equipment is not nearly so obvious, but it is just as real and often much more serious. The reason for this is that the possession of machinery and its availability for use costs something whether it is actually being employed or not. If it is being used, the cost of its operation is transferred to the output during that time whose value is increased by the normal amount of the cost of operation of machinery for the time involved. If the machine is idle, this cost is a loss and should be treated and thought of as such. This question was discussed at some length in Chapter V and the problem under discussion here is simply another illustration of the influence of idle machinery on factory problems. It is so frequently overlooked in actual practice and its importance is so great that it is worth constant emphasis.

It should be evident from the foregoing paragraphs why adequate attention should be given the problem of maintenance and repairs and why the factory manager should be particularly interested in its solution. The problem is a general one, common to all kinds and types of industry, and one which is ever present, no matter how varied may be the forms which it takes.

Classification of maintenance and upkeep.—To solve this problem it is usually helpful to divide up the various kinds of maintenance and upkeep in such a way that they may be dealt with as classes and not as individual items. There are, in most cases, two principal kinds of maintenance work, one of which may be further conveniently divided into two sections.

1. Repairs and maintenance work coming at regular intervals which can be forecasted more or less definitely.
    a. Repairs and maintenance work coming at regular and frequent intervals, e.g., one month or less.
    b. Repairs and maintenance work coming at regular but longer intervals.
2. Repairs and maintenance work coming at irregular intervals due to accidental and unforeseen causes.

Accidental repairs should be reduced to a minimum.—It is obvious that it is the latter class of maintenance work which is likely to cause the greatest amount of trouble, and cause that idleness of machinery and that upsetting of schedules which results in such heavy losses. Hence work of this type should be reduced to a minimum and maintenance work as far as possible controlled in such a way as to bring it into the first class. It is impossible, naturally, to avoid all accidental breakdowns and their consequent repairs. No matter how thoroughly the problem is studied or how carefully plans are laid to forestall any breaks which will interfere with the operation of the machines, occasional accidents will occur and due provision must be made for handling them.

It will be found in most cases, however, that there is far too much maintenance work carried on on the "accidental" basis and that much of it can be controlled so that it will be taken out of this class and placed in that of the regular upkeep. The "accidental" repairs are always the more expensive, for they are the result of, and in turn cause, emergencies which must be handled promptly regardless of expense. The reason for this is largely that the whole problem has been neglected, its importance being appreciated and adequate attention given it only in recent years.

The planning of maintenance work.—To a considerable degree the solution of this problem depends on the planning of work which is to be done. So much has been accomplished in connection with the planning of production that the idea of forecasting the work to be performed and of preparing for it is now generally understood. It seems rather difficult, however, at first glance, to see how repairs can be forecasted and planned. It is necessary, in order to accomplish this, to act on the principle of making the repair before the absolute necessity of immediate action occurs. The application of this depends, in the first place, on a careful study to see how often maintenance work should be done and to determine the standards of condition; and, secondly, on a thorough inspection to see that the work is done and to discover any place which seems to be in need of attention. Lastly, it is desirable to establish a mechanism for the control of the actual work so that the tasks may be performed in a minimum amount of time and with a minimum of effort.

Scheduling plant upkeep.—In the first section of the first group was placed that maintenance work which comes at frequent intervals. This usually includes the tasks which are the easiest to control. It is not difficult to determine, for example, that floors should be swept every day or every week, that windows should be washed every fortnight or every month, or that machines or shafts should be oiled and belts tightened at regular intervals. It requires more study, perhaps, to decide how much oil should be given to a machine each time, or what the proper tension for various belts should be; but in all such cases a little investigation will usually reveal the desired facts.

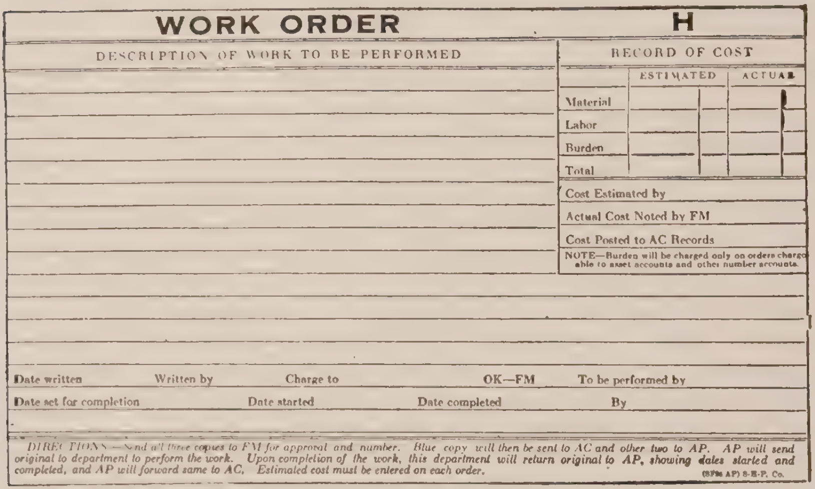
In the case of machines which need to be taken down and overhauled from time to time, the determination of how often this should be done and the standards of conditions—how much certain parts may be worn before they are replaced, for example—to be maintained are a little more difficult to establish, but there is nothing impossible about the task.

The control of factory housekeeping.—The actual task of the control of these several kinds of maintenance work should not offer any serious trouble. In the case of sweeping the floors, for instance, a definite space may be assigned to each janitor and a time at which he should begin his task. What he is to do and how he is to accomplish it should be given him in the form of standard practice instructions, which should contain complete directions for the doing of the work allotted to him. He should be supervised by the head janitor and his work inspected from time to time by an inspector.

The control of regular but infrequent maintenance.—In the case of the maintenance and repair work to be done at relatively long intervals, like the overhauling of machinery, the painting of the building, the general maintenance of the roof, floors, foundation, stairs, etc., the mechanism needed is usually somewhat more complicated because of the greater complexity of the problem. It is necessary to take into consideration the materials, workers, equipment and orders necessary to do the work. All of these elements must be ready if the repairs are to be done on time. Material must be on the spot, not in the warehouse of some dealer; repair parts, for example, must often be ordered from a distance and it is useless to take down a machine unless they are at hand to replace the worn parts which are removed.

The same thing applies in the case of workers and equipment. It is useless to expect repairs to be made unless the men are available and the equipment which they are to use is ready for them. All of these materials, workers, and equipment would stand idle if the necessary orders were not forthcoming.

The basis for control of this kind of maintenance work is the work order (see Figure 44) which is issued when it is time to schedule the work to be done. The time when it is to be started can best be called to the attention of those who have control of this work by means of a tickler card, filed in a tickler file. Such a card contains the information that such and such a job is to be done. It is then put in the tickler file for a date a week in advance of the time when it is desired to schedule the job. The effort should be made, of course, to pick periods when the machinery to be overhauled is least busy and that means, in most cases, during the dull season. If this is done, the regular work of production is interrupted little or none at all, and often some of the older and more intelligent factory hands can be added to the repair gang, thus keeping them busy and adding to their knowledge of the machinery which they ordinarily control.



WORK ORDER **H**

DESCRIPTION OF WORK TO BE PERFORMED

RECORD OF COST

	ESTIMATED	ACTUAL
Material		
Labor		
Burden		
Total		

Cost Estimated by

Actual Cost Noted by FM

Cost Posted to AC Records

NOTE—Burden will be charged only on orders chargeable to asset accounts and other number accounts.

Date written Written by Charge to OK—FM To be performed by

Date set for completion Date started Date completed By

DIRECTIONS.—Send all three copies to FM for approval and number. Blue copy will then be sent to AC and other two to AP. AP will send original to department to perform the work. Upon completion of the work, this department will return original to AP, showing dates started and completed, and AP will forward same to AC. Estimated cost must be entered on each order.

(8Fm AP) S-E-P. Co.

By Courtesy of the Square D Co.

Fig. 44.—Work Order.

If there is special material needed for the job, the work should be scheduled some time in advance of the date when actual operations are to be performed, thus giving time to procure the needed material or parts. The repairs should be scheduled on some such form as that illustrated in Figure 45,

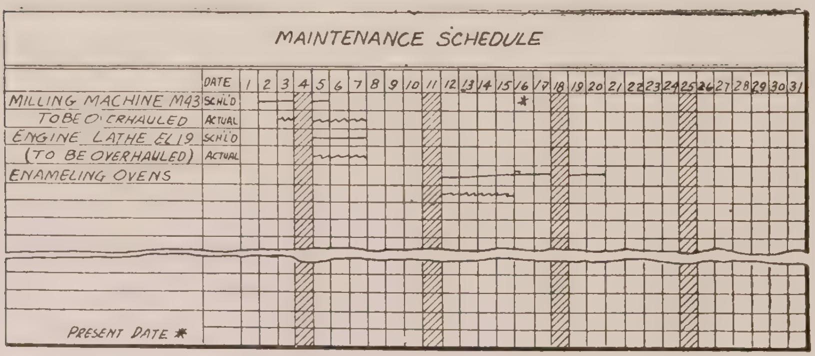
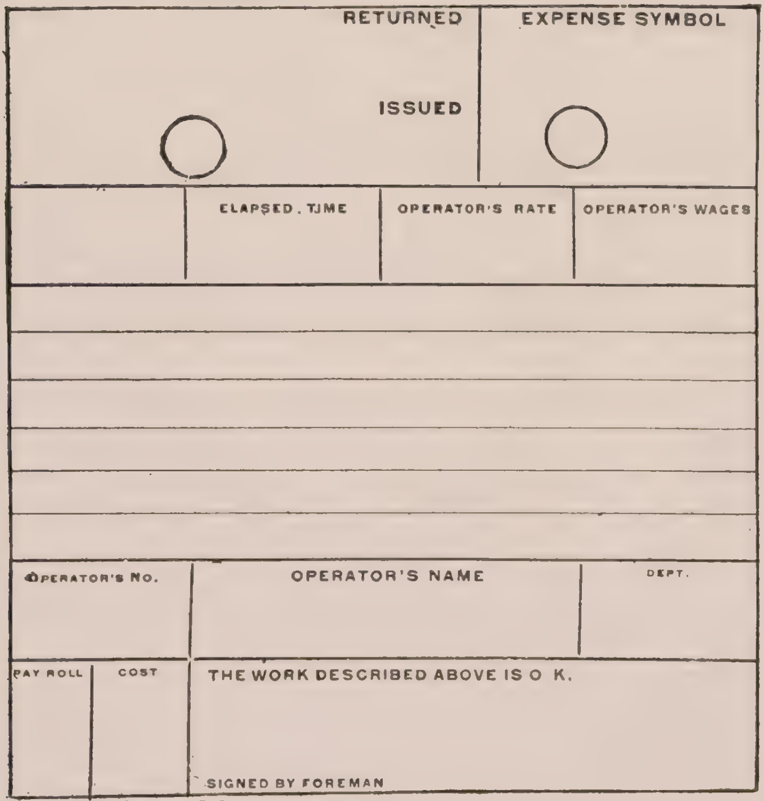


Fig. 45.—Maintenance Schedule.

two lines being allowed for each job, one for the graphic scheduling of the work to be done and the other for the graphing of its accomplishment. This permits a comparison between the two. If equipment is needed for a variety of tasks and there is any danger that it will be called for by two jobs at the same time, it can be scheduled in the same way as the job itself. It is also desirable to schedule the workers' time in advance, so that more work may not be planned for them than they are capable of performing. In fact, in many cases this part of the schedule should be the first to be prepared for that reason. It is wise to schedule only a portion of the workers' time, so that leeway may be allowed to take care of the emergency repairs which are sure to come up from time to time, and also for the reason that it is seldom possible to forecast the length of time which a job of overhauling a machine will take.



RETURNED
ISSUED
EXPENSE SYMBOL

	ELAPSED. TIME	OPERATOR'S RATE	OPERATOR'S WAGES

OPERATOR'S NO.	OPERATOR'S NAME	DEPT.

PAY ROLL	COST	THE WORK DESCRIBED ABOVE IS O K. SIGNED BY FOREMAN

By Courtesy of the Square D Co.

Fig. 46.—Maintenance Time Ticket.

Once the schedule is prepared the next step is to put it into effect by dispatching the work. This can frequently be accomplished to advantage by means of the time tickets (see Figure 46) which should be made out for the repair gang in advance on the basis of the order which has been issued. When the schedule shows that it is time for the job to be done, the time tickets should be put on a dispatch board in the plant engineer's office like that shown in Figure 47 under the heading of "next job," the tickets being distributed according to the men affected. As soon as the men have finished the job they are working upon, these time tickets should be moved up to the "job or process" position and the men assigned to the job. This board shows at all times where each man of the repair force is, what he is doing, when he started, and—if the forecasted length of time required of the job is entered on the time ticket—the probable length of time which he will be on the job. It also shows the next job and indicates whether any of the men are likely to be out of work soon or are being unduly crowded. If an emergency job comes up it is easy to ascertain which man can be most conveniently taken off his present job and assigned to it.

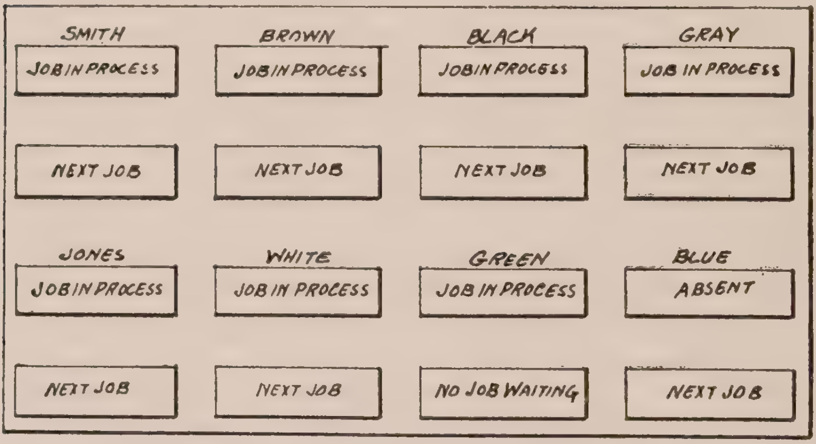


Fig. 47.—Dispatch Board for Maintenance Control.

Once any repair job is completed, it should be inspected and the order should not be considered as complete until the job is reported as satisfactory. With the tickler file, schedules, dispatch board and final inspection there should be no difficulty in controlling maintenance and repair work which comes at regular though infrequent intervals.

The organization for the maintenance of the plant need not be very complex even for a fairly good sized plant. The head of this work is usually a plant engineer and under his direction come the several foremen who are in charge of the various phases of the maintenance and repair work and who do the actual supervision of the several jobs. If the size of the department warrants it, a clerk may be added to operate the system for the control of the various tasks under the direction of the plant engineer. This organization is shown in Figure 48. It is desirable, of course, for the plant engineer to have regular conferences with foremen so that work which overlaps may be properly distributed and gaps avoided. It is also well to concentrate the intelligence and experience of several individuals on the tasks which offer serious problems.

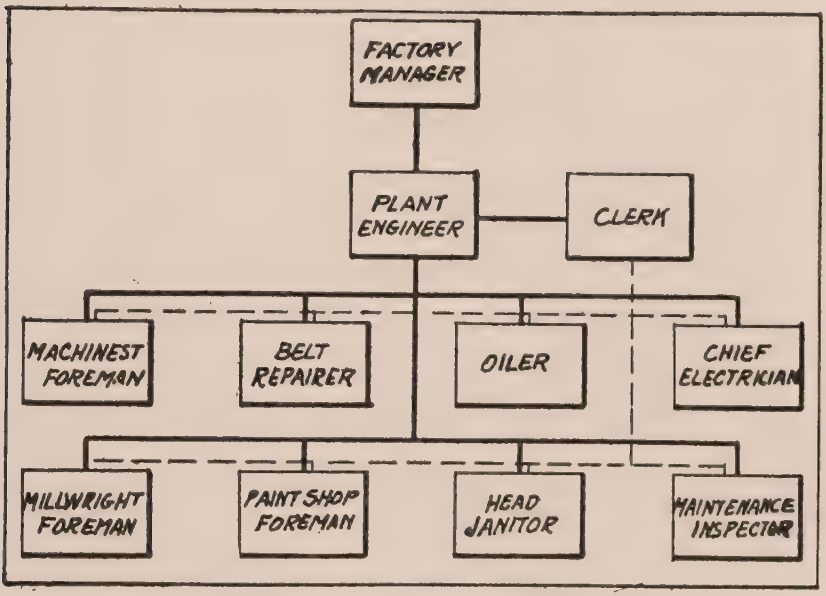


Fig. 48.—Organization of Maintenance Work.

The adequate maintenance of the plant and its equipment is a prime necessity both for the control of production and economy of operation. The solution of the problem which it presents depends principally on the forecasting of the need of maintenance work, constant inspection to see that it is properly done and to catch probable breaks before they occur, the establishment of some simple system of control, and the workmanlike performance of the jobs to be done.

References for Additional Reading.

"Library of Factory Management," Vol. I, Chapters XX and XXI; Vol. II, Chapter XII.

CHAPTER XI

MATERIALS—THEIR SPECIFICATIONS AND CLASSIFICATION

Purposes of this chapter.—

1. To study the problem of the choice of materials.
2. To investigate the setting of material standards.

The approach to the problem of the choice of materials for use in factory should be: (1) To analyze the needs which the materials must meet, and (2) To analyze the kinds of materials available to meet these needs.

To a large extent the analysis of the needs is an analysis of the finished product, for where the product demands tensile strength, for example, the same quality is essential in the material out of which it is to be composed. The analysis of the needs, therefore, resolves itself largely into the determination of the various characteristics required in the finished product. Frequently this means the balancing of one characteristic or quality against another. Secondly, the needs to be studied are found in the requirements of the manufacturing processes through which the material is to pass. A sheet-steel box cover with sufficient rigidity to resist possible blows is desired. On the other hand, it is found that a box cover made of steel hard and tough enough to resist such blows is an expensive article to fabricate. In order to produce it at a reasonable cost it is necessary to use softer steel than is strictly desirable from the standpoint of the finished product.

Characteristics of materials.—Such a problem as this is constantly being encountered in regard to conflict of qualities desired in use as well as in manufacture. It is found many times in the manufacture of electrical goods, where certain electrical and mechanical qualities are desired in the same object.

The number of characteristics which must be considered are many and varied. They include:

- I. Mechanical.
  - A. Strength of the material.
    - 1. Tensile strength.
    - 2. Strength in compression.
    - 3. Strength in shear.
    - 4. Strength in torsion.
  - B. Durability in mechanical use.
  - C. Elasticity.
  - D. Compressibility.
- II. Electrical.
  - A. Conductivity.
  - B. Di-electric capacity.
  - C. Impermeability.
- III. Heat.
  - A. Conductivity.
  - B. Specific heat.
- IV. Light.
  - A. Color.
  - B. Reflection.
  - C. Sensitiveness.

There are many other characteristics too numerous to mention.

The selection of materials.—Once the needs to be met are determined it is necessary to study possible materials to decide which one can most nearly meet the requirements. The answer to this question depends on a familiarity with materials and their characteristics or qualities. Fortunately there is a substantial body of knowledge available for those who are confronted with this problem. Many experiments have been performed and a number of valuable treatises have been prepared on the properties of materials. In spite of this fact, however, it is often necessary for an individual plant to do not a little further experimenting in order to select exactly the right material to meet the needs which have been ascertained. This task belongs to the departments engaged in the design and development of the product.

The specification of materials.—When the materials have been selected, it is necessary to record a description of them in the form of a specification. The first draft of a specification is properly a duty to be performed by the above-named departments. In most cases, such specifications are too exact and too rigid to be of much practical use. Hence it is necessary to prepare a second draft in which permissible deviations from the exact standard set are recorded. Because of its intimate contact with the shops and because one of its principal duties is to establish manufacturing standards of all kinds and especially operation standards, the Manufacturing Standards Department is the most logical, and usually the most practical place, in which to have the working specifications prepared.

The most familiar form which specifications take is found in linear dimensions. In such cases, the tolerances are customarily expressed as plus or minus (+ or —) a certain fraction of an inch, though occasionally as a percentage of the exact dimension.

Specifications may take other forms, however. The composition of steel is specified according to the percentage of the various elements contained therein. Many other materials are specified by means of a chemical formula.

Other kinds of specifications.—In the case of colors and other attributes for which standards have not been established, it becomes necessary to express tolerances in terms of true, purity, and luminosity, and to do this is rather difficult. In practice, sample color cards are often employed for defining colors, and the comparison of actual with the real depends, to a considerable extent, on the training of the human eye.

Specifications from the economic viewpoint.—The setting of working standards for materials has so far been discussed largely from the technical point of view. The commercial or economic standpoint must not be overlooked in this connection, however.

The first factor to be considered in this connection is the shop, and here conflicting interests are found. In so far as the shop is a producer of parts, it likes to have the tolerances liberal so as to permit an increase in the speed of operation and a reduction in the number of parts rejected at inspection. As a consumer of those parts in the assembly of the finished product, however, the shop is interested in having the tolerances rather narrow so as to permit the rapid and easy assembling of those parts. Somewhere between these two needs a happy medium must be found for satisfactory factory operation.

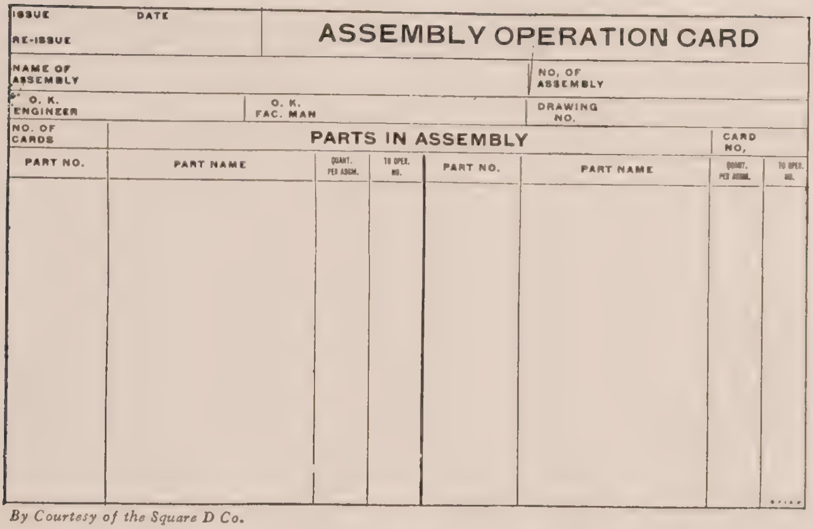
There is still another phase of the setting of material standards which is of vital importance from the point of view of the shop—the reduction in the number of parts or amount of materials to a minimum—the standardization, in other words, of the product and its components. It has already been pointed out in an earlier chapter that this was a great aid to the simplification of the problems of planning production and actually getting it out in the shops; but it is a point which will bear reiterating because it is so important, and because in many cases it is overlooked.

The use of materials or parts which are commercially standard means a reduction in the number to be purchased or made in most instances it provides specifications which have been worked out with great care and in most cases the production of standard parts and materials involves only the use of standard machines, tools, and processes which are readily available. The utilization of parts which are standard for the same company gives much the same advantages but in a lesser degree.

Every effort toward simplification should be made, therefore, before the specification of materials and parts is undertaken. Simplification promotes lower costs both in the preparation of the material standards because of the smaller number which are needed, and in their use, for the same reason.

Some consideration must also be given to the commercial availability and the cost of the materials which are specified. It must never be forgotten that the goods must be manufactured for a profit and that the expenditure for materials is one of the costs of production. Hence, it is sometimes necessary to select and specify a material which does not come up to what is desired for the particular purpose, but which will serve, nevertheless, and which must be chosen because of the lower cost which it involves.

Recording the specifications.—After the needs for materials have been determined, the selection made, and the working standards and specifications decided upon, there still remains the task of recording the specifications and classifying and symbolizing the materials to promote ease of their control.



ISSUE DATE
RE-ISSUE

ASSEMBLY OPERATION CARD

NAME OF ASSEMBLY
NO. OF ASSEMBLY
O. K. ENGINEER
O. K. FAC. MAN
DRAWING NO.
NO. OF CARDS

PARTS IN ASSEMBLY

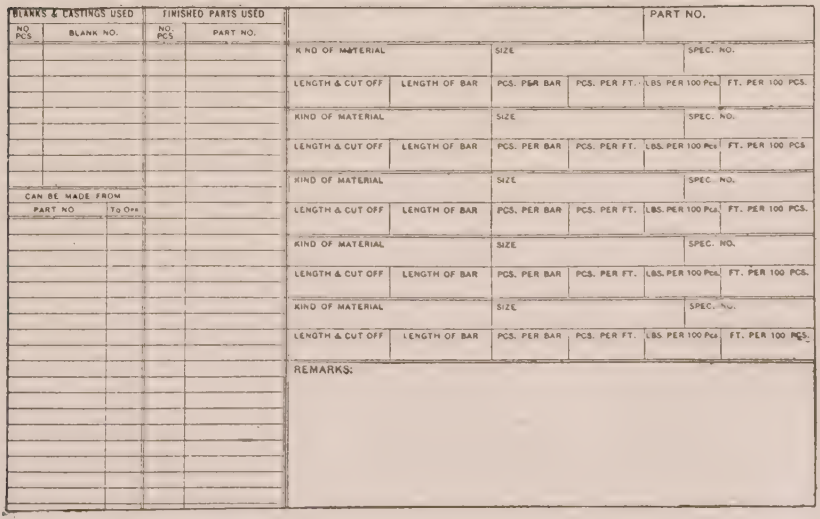
CARD NO.

PART NO.	PART NAME	QUANT. PER ASSEM.	TO OPER. NO.	PART NO.	PART NAME	QUANT. PER ASSEM.	TO OPER. NO.

By Courtesy of the Square D Co.

Fig. 49.—Assembly Operation Card Showing Record of Parts Required for Assembly.

The forms which a record of the specification takes are varied. Drawings are frequently used for this purpose; chemical symbols, a written description, and samples, are other



BLANKS & CASTINGS USED
NO PCS | BLANK NO.
FINISHED PARTS USED
NO. PCS | PART NO.
CAN BE MADE FROM
PART NO | To Ope

PART NO.

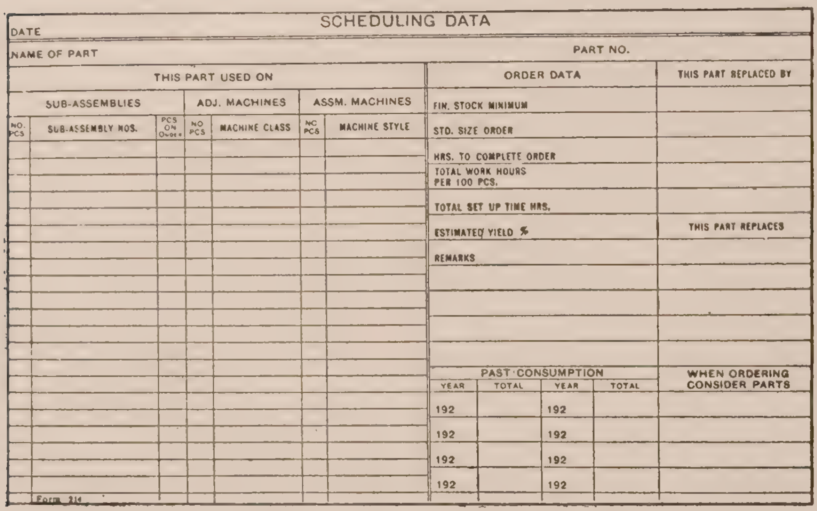
KIND OF MATERIAL		SIZE			SPEC. NO.
LENGTH & CUT OFF	LENGTH OF BAR	PCS. PER BAR	PCS. PER FT.	LBS. PER 100 PCS.	FT. PER 100 PCS.
KIND OF MATERIAL		SIZE			SPEC. NO.
LENGTH & CUT OFF	LENGTH OF BAR	PCS. PER BAR	PCS. PER FT.	LBS. PER 100 PCS.	FT. PER 100 PCS.
KIND OF MATERIAL		SIZE			SPEC. NO.
LENGTH & CUT OFF	LENGTH OF BAR	PCS. PER BAR	PCS. PER FT.	LBS. PER 100 PCS.	FT. PER 100 PCS.
KIND OF MATERIAL		SIZE			SPEC. NO.
LENGTH & CUT OFF	LENGTH OF BAR	PCS. PER BAR	PCS. PER FT.	LBS. PER 100 PCS.	FT. PER 100 PCS.
KIND OF MATERIAL		SIZE			SPEC. NO.
LENGTH & CUT OFF	LENGTH OF BAR	PCS. PER BAR	PCS. PER FT.	LBS. PER 100 PCS.	FT. PER 100 PCS.

REMARKS:

By Courtesy of Union Special Machine Co.

Fig. 50A.—Specification Card for Materials and Parts—Obverse.

means employed under certain circumstances. For the use of the Planning Department, special forms of specifications designed to aid in the planning and scheduling of the work are frequently desirable. Two illustrations of such forms are shown in Figures 49 and 50.



SCHEDULING DATA

DATE

NAME OF PART

PART NO.

THIS PART USED ON						
SUB-ASSEMBLIES			ADJ. MACHINES		ASSM. MACHINES	
NO. PCS	SUB-ASSEMBLY NOS.	PCS ON ORDER	NO PCS	MACHINE CLASS	NO PCS	MACHINE STYLE

ORDER DATA	THIS PART REPLACED BY
FIN. STOCK MINIMUM	
STD. SIZE ORDER	
HRS. TO COMPLETE ORDER	
TOTAL WORK HOURS PER 100 PCS.	
TOTAL SET UP TIME HRS.	
ESTIMATED YIELD %	THIS PART REPLACES
REMARKS	

PAST CONSUMPTION				WHEN ORDERING CONSIDER PARTS
YEAR	TOTAL	YEAR	TOTAL	
192		192		
192		192		
192		192		
192		192		

Form 214

Fig. 50B.—Specification Card—Reverse.

It will usually be found that the classification of materials can best be worked out on the basis of either purpose or kind of material. Purpose or use within the plant is usually found to be most convenient for parts and supplies; and kind of material for raw materials and product, though local conditions may modify this somewhat.

Symbolization of materials.—Once the materials are classified, they should then be symbolized. The development of a satisfactory set of symbols furnishes one of the most important aids to the current handling and recording of materials. It is desirable that both the classification and symbolization of materials should form a part of the classification and symbolization of all the various elements with which the manager's work is concerned, and hence further discussion of them is postponed to the chapter dealing entirely with the subjects.

Conclusion.—The task of setting the material standards and drawing up the specifications is usually centralized in the

Engineering Department, or the department which corresponds to this one when it is otherwise named. In so far as modifications are needed to meet manufacturing requirements, the Manufacturing Standards Department should have a hand in the question. This part usually takes the form of approval of specifications, tentatively prepared, or their disapproval accompanied by suggestions. The same can be said in regard to the Purchasing Department in so far as materials bought outside are concerned. In the preparation of the design and specifications of the merchandise, the Sales Department should likewise be consulted. This is usually the first step, as the design of the product is likely to affect the materials selected. In short, a final decision should be the result of conferences to settle debated points, conferences which should be approached by all concerned in the spirit of trying to do the best thing for the company as a whole, and which should leave all interested parties satisfied that the best possible choice has been made even though it affects their own function adversely.

References for Additional Reading.

Cartmell, M., "Stores and Material Control," Chapters VIII, XII.
Farquhar, H. H., "Factory Stores Keeping," Chapter IX.
Radford, G. S., "The Control of Quality in Manufacturing," Chapters XIII-XV, XVIII, XXI.
Thompson, C. B., "Scientific Management," pages 490-508.

CHAPTER XII

THE SELECTION OF THE WORKERS

Purposes of this chapter.—

1. To consider the workers as a means of production.
2. To study the basis for the selection of workers.
3. To outline the methods of selection.

It is evident to even the most casual student of manufacturing administration that the workers are one of the most important factors of production with which the factory manager has to deal. Even when highly developed automatic machinery is used, it is impossible to dispense entirely with workers, and in some factories, at the present time, most of the work is hand work where the employees not only guide the tools, but also furnish the power to drive them. From one point of view, therefore, the workmen in the factory are very much like machines and materials—units which the factory manager employs to accomplish his task.

Workers as a part of our social organization.—This is, of course, only one side of the problem, and, when looked at as a whole, the less important side as compared with the consideration which should be given workers as human beings, and as members of our social organization. It is right and proper that their health and well-being should receive consideration before their utility as units in the productive machine. For a factory executive to give this phase consideration is good judgment, quite aside from any moral questions which may be involved, for to do so results, in most cases, in more effective workers and, hence, in better and less costly work.

The intelligent management of workers is so important a part of the administration of a business as a whole, and of a factory in particular, since the larger part of the employees of a manufacturing enterprise are located there, that it properly forms a subject by itself which deserves for its treatment as large a volume as the present one. As space is lacking here for any such lengthy discussion of the subject, consideration will be given only to the first mentioned phase of the problem —the workers as a means of production—granting the human side of the matter is the more important.

The basis for the selection of workers.—The basis for the selection of the workers should be the same as the basis for the selection of materials, namely, the need for which the workers are to be selected. As the employees are to be chosen for the things which they are to do, the way to attack the problem is by a study of the various operations which they are expected to perform.

This analysis of operations is often called "job analysis," a term which is sometimes used to describe a somewhat similar and closely related process—time and motion study for the purpose of setting operation standards. Both of these studies have the same subject matter, but they have frequently been carried on by different individuals with different ultimate objects in mind. Both of them have as their immediate goals the obtaining of information about the job, but one is for the purpose of deciding what kind of a worker is best fitted for the job and the other is to determine the best method for performing the task. The making of time and motion studies for the setting of operation standards is considered in a subsequent chapter so that attention is given here only to those investigations which are necessary as a basis for deciding what kind of worker is needed for the job.

Fundamentally, both time and motion studies and job analyses have much in common. Both must be predicated on standardized conditions of material, machinery, tools, and surroundings. For the final studies on which the operation of standards is actually based, a "standard" or normal worker—in terms of the work to be done—is assumed. One of the troubles which have been encountered in the past in the making of job analyses is that conditions have not been standardized, and that the person making the study has not known enough about the job to appreciate this fact, or, if he did, to know how to accomplish the necessary standardization. As a result, job analyses have not produced the satisfactory results which should reasonably be expected. It is usually wise to have the actual study of job made by some one from the Manufacturing Standards Department who knows what standard conditions should be and is in a position to establish them, if they have not already been set up. He may well be assisted, and the results of the study interpreted, by some one from the Employment or Personnel Department, who is in a position to understand the problems involved in the actual selection of the workers.

Elements of employee specifications.—In preparing specifications of the kind of workers wanted for certain jobs, or for the operation of particular machines, there are three sets of characteristics which demand consideration. In the first place, the physical requirements must be decided upon. Does the work require strength, continuously or intermittently? Is it a task which demands nervous energy or a phlegmatic disposition? What is the height of the employee which will enable him to work with the minimum of fatigue? Is specially good hearing or eyesight, or tactile sensibility necessary? Is deftness important? Is stamina and endurance essential? These are only a few examples of the physical characteristics, the importance of which, in any individual, differs according to the peculiarities of the job under consideration.

A particular case or two will help to make this point clearer. The man who is to be selected to operate a 14 or 16 inch engine lathe should have certain physical attributes. He should be moderately strong, but does not need to be heavily muscled, as there are few jobs which come to this size of lathe which demand a great amount of strength. He should be of medium height, as a very tall man would find it necessary to stoop a good deal of the time in order to see his work.

A short man, on the other hand, might be used by having a platform which would raise him several inches made for his benefit. He will need to have good eyesight, as he will often be required to work to small tolerances. He should be able to read micrometers and precision measuring instruments with accuracy. He should be able to stand on his feet during most, if not all, of the day, for with a large part of his work it is necessary for him to give his attention to it so completely that he would not be able to sit down, even though a chair were provided.

He should have intellectual ability in order to be able to do his work successfully. He needs to be familiar with shop mathematics, including the rudiments of trigonometry. He must be able to read simple directions in English and be able to understand drawings, especially orthographic mechanical drawings, and blue-prints, for most of the written instructions which he will receive will be in the form of blue-prints, or be accompanied by them. He should be familiar with all kinds of lathe tools—turning, thread cutting, boring, drilling, reaming, tapping, etc.—and the way in which they are used. He should understand the construction of his machine and its attachments, especially the change-speed gears, taper-turning attachments, chucks, face-plate and its attachments, etc. He should know how to use various kinds of gauges—micrometers and calipers, both inside and outside, protractors, snap, plug, and thread and special gauges. He should also know something about the various metals which he will be expected to cut, and their metallurgy. He should also understand how the belts are used and cared for which drive his machine. To be a first-class engine lathe hand requires not a little technical education. In actual practice, of course, many men are employed to do one particular operation on an engine lathe on a single part, and for them far less intellectual training is necessary.

In addition, there are certain moral qualities which a competent engine lathe hand should possess. He needs to be careful, painstaking, and patient. The control of his machine depends almost entirely on him, and if he does not do his work conscientiously, it is very likely to be spoiled. He should possess those qualities, in other words, which characterize a man as reliable. It is highly desirable to add to these, other qualities which mark a man as a thoroughly dependable, conscientious, industrious workman.

Contrary to what might be expected, the moral qualities are the most important after the minimum physical and intellectual characteristics have been met. If a man possesses adequate moral stamina, he will fill any gaps in his education or training. More and more, appreciation is being accorded this fact. It is difficult, nevertheless, to determine what these essential moral qualities are, and even more difficult to measure or evaluate them.

The physical requirements and, to a large extent, the intellectual qualities may be determined as the result of the time studies which are necessary for the setting of the operation standards, but the evaluation of the moral qualities depends largely on the judgment of the person who is giving them consideration.

Specifications of the kind of employee wanted should not be limited to the manual workers in the shop. Such specifications should be prepared for all the permanent employees of the business from the general manager down to the bell-boy. It is impossible to hire satisfactory workers unless the kind of worker wanted has been carefully defined. It is essential to reduce specifications to definite, written form. Many times specifications exist in a more or less hazy state in the minds of the employment manager, production manager, foreman, etc. Such mental records, however, are always indefinite, and seldom is the same idea of the requirements of a particular position held by all those who have occasion to deal with it. The only safe course to follow is to prepare written specifications. A few practical examples will serve better than a description to show how this may be done. It should be noted, however, that most of these specifications are lacking in that they give no record of the moral qualities desired.

Turret lathe hand[1] — *Description.* — For the purpose of this description of occupations it is understood that a turret lathe hand has the following general qualifications:

Qualifications.—The turret lathe hand must read drawings sufficiently well to get a thorough understanding of all mechanical requirements. He must know the names, care, and use of the principal parts of the machine and the machine attachments. He must know the names, care, and use of all standard toolroom tools, and must use skillfully such measuring tools as scales, inside and outside calipers, inside and outside micrometers, combination square, bevel protractor, snap, plug, and thread and special gauges. He must use skillfully all standard tools. He must do chucking, facing, boring, drilling, reaming, and turning. He must be familiar with the use of special boring bars, drills, reamers, and taps. In addition to possessing this general knowledge, he must be able to order and set up tools for any given piece of work on a specified machine.

Schooling.—Common school.

---

[1] This and the following illustrations are from bulletins of the United Employment Service, the United States Bureau of Labor Statistics.

It should be evident to the reader that this general specification could be improved materially, especially for a particular factory. The qualifications could be made more specific and definite and the intellectual requirements be expressed more clearly, perhaps. This specification, however, marks a long step forward in the right direction, for it reduces the needs to be met to writing and forms a basis, even though not a thoroughly satisfactory one, for making a selection of workers.

Another illustration taken from a field of interest to the factory executive is briefer:

Storekeeper —*Description.*—The storekeeper makes requisitions, receives and inspects, stores, issues upon proper requisitions, classifies and accounts for materials, supplies and stores in the storeroom, storehouse, or yard.

Qualifications.—He must be able to keep accurate records of materials, supplies, and stores issued, and make reports to the office, and must see that the goods in his charge are properly stowed and watched.

Schooling—Common school.

A third and final example is that of the specifications for a production manager:

Production manager.—The production manager plans the work in the factory and sees that it is efficiently conducted.

Qualifications.—He must have a broad point of view, the power to direct others, and the ability to delegate work which can be done by others. He must have a thorough knowledge of factory and shop conditions. He must have an analytical mind and executive ability of a high order. He should be enthusiastic, tolerant, firm, tactful and resourceful.

Schooling.—High school; higher education desirable; technical education or courses in scientific management and allied branches.

Here is an example of where attention is given to the necessity of certain moral qualities—tact, tolerance, firmness, etc.—although they are not grouped under this head. It would be much more helpful if these qualities and the intellectual and physical characteristics were distinctly separated in the specification.

The use of employee specifications in the control of production.—These specifications are of benefit, not alone to the employment manager who has the task of selecting the employees in the first place, but also to the production manager, foremen, and others who are to supervise them at their work. Under the best of circumstances it is difficult enough to make a wise selection in the first instance, and, hence, it is not surprising that workers who are not well adapted to the tasks to which they are assigned are sometimes hired. Such specifications furnish the basis for noting whether an employee is failing to make good because of lack of will to do so, or because he is really a misfit in his present place.

The benefits of employee specifications to the workers.—The specifications also serve as a basis for the training or upgrading of workers. It lets the workers know the requisites for a higher position for which they may wish to fit themselves. It aids the management in its task of arranging a regular progression of jobs so that the simpler ones may lead up in a systematic fashion to the more complex.

In still another way are such specifications of value to the factory executives. When employees have been at work long enough so that their capabilities may be evaluated with some degree of accuracy, a record thereof may be prepared. When such a record is compared with the specifications of the various jobs, it is possible to decide for what kinds of work an employee is fitted, and from such a comparison the flexibility of the working force may be determined. It is often very important, especially in the jobbing type of industry, for the management to know what jobs each of its employees is capable of performing, for such information enables it to shift workers in a way to promote maximum production, low costs, and ease of control.

The selection of the workers.—The most important use of employee specifications is probably in the original selection of employees. It would be just as sensible to tell the purchasing agent to buy a ton of steel and expect him to get the right kind, without any further specification, as it is to tell an employment manager to hire ten machinists without any additional explanation of what is wanted. Employee specifications should meet this need and give the employment manager a clear conception of what is wanted. They should be supplemented by the use of scientifically prepared tests which will aid the employment manager in selecting employees meeting the requirements established by the specifications.

With such a basis to work upon, the employment manager is in a position to pick the workers which he has been asked to get from among the applicants which come to his office. Requisitions should be sent to him for workers in much the same way that they are sent to the purchasing agent for material. Workers should not be hired from outside as long as there are any available for the job under consideration within the plant. Often this means a readjustment of working force. The first step in this direction can often be taken by the Planning Department if it has in its files records of both the specifications for employees and those of the tasks which each employee can do. A second step, and one which can also be taken in the first instance if the Planning Department is not equipped to make the change suggested, is for the Employment Department to check what has been done or to make the original adjustment, if it has not been effected.

Conclusion.—From one point of view the workers are a means of production and must so be considered by the factory manager, who should realize at the same time that the human side of the question is the bigger and more important matter in this connection. To be able to select the desired employees, it is necessary to ascertain what qualities are necessary for certain jobs on the part of the employees—qualities which can best be grouped under the head of physical, intellectual, and moral—and these requisites once determined should be reduced to writing in the form of employee specifications. The employees should be requisitioned and hired on the basis of these specifications which should also be used in connection with a record of the capacities of each individual to do more than one job. Such a plan as this lays the foundation for the adequate control of the workers in the same way that material specifications lay the foundation for the control of materials.

References for Additional Reading.

Scott and Clothier, "Personnel Management," Chapters VIII, IX.

Tead and Metcalf, "Personnel Administration," Chapters XVII-XIX.

CHAPTER XIII

MANUFACTURING STANDARDS

Purpose of this chapter.—To study the scope and significance of manufacturing standards.

There remains one more means of production to be considered—manufacturing standards. Fundamentally, manufacturing standards are standards for operations in the shop and standard methods for the control of the manufacturing processes. As such standards are so largely dependent on standards for equipment, materials, and workers, the latter are usually included under the head of manufacturing standards, especially in so far as their development is concerned.

Standards, a means of "transfer of thought, skill and intelligence."—The establishment of standards for operations and methods is simply one way of carrying over from one person to another and from one period to another, the results of careful scientific investigation to determine the procedure for the performance of the daily tasks about the plant. It is an instance of the "transfer of thought, skill and intelligence" which is so much discussed by many economists, and which is a conception which should receive much more consideration from practical business men than it has yet.

In so far as the workers are concerned, the setting of standard ways of doing things is a direct aid to them in their work, for it furnishes a basis for acquiring habits of action which reduce the amount of labor. The first time a certain task is performed, it takes longer and necessitates much more mental and physical effort than it does the second time, and more the second time than it does thereafter. The acquisition of habits is largely a matter of training, it is true, but people can learn to do things well or poorly; they may be well or ill-trained. To be most effective, the habits acquired must be good ones, and it is here that the standards of operation and control play their part.

It is seldom that a worker can develop on his own responsibility the best method of doing his work. In the first place, he seldom has had sufficient training in the fundamentals of the work which he is doing to be able to decide whether the method which he is employing is the best one or not. He lacks the experience which is essential to the formation of a sound judgment in the matter. He sees only a part of the work and is not in a position to appreciate the relation of his task to the whole process of turning out the part or product on which he is working. It would be just as reasonable to expect a workman to select the proper material for making some part of an automobile when he had never seen the entire car, but only the part on which he was working, as it would be to expect him to decide upon the best method of producing it. Very rarely, too, does a worker, even if he has the necessary training and experience for the setting of standards, have sufficient time to do so, for in most cases his time is fully occupied with the immediate task. Hence, while standards of some kind, rough and inadequate as they may be, must exist before any work can be done, satisfactory standards which promote efficiency of operation in all departments can be established only after careful study by those who are competent for this task and who have the time to devote to it. While they are not a means of production in the same sense as are equipment, materials, and workers, they are so essential to the successful utilization of these that they may be properly classed with them.

The development of standards.—The standards which are the most important are those for operations in the shop and for the routine control leading up to these operations. This last group includes the routine tasks of all the manufacturing departments as their work directly or indirectly leads up to the control of the work in the shops. Before going on to a discussion of these standards, it is desirable to survey briefly some of the other standards which are often grouped with operation standards under the head of manufacturing standards, and which must be tentatively established before the task of setting operation-standards may be entered upon. The word "tentatively" is used advisedly in this connection, for it will be found that, in setting any standard, it is often necessary to use some other standards which, in turn, directly or indirectly depend upon the first one. To solve such a problem it is necessary to make use of temporary standards, which are as near the permanent standards as possible, as a starting point. Standards, like everything else connected with a business, are interlocked to a surprising degree, and it will be found that in dealing with one it is necessary to give consideration to others also.

Operation standards are dependent upon the setting of standards for:

1. Product.
2. Materials.
3. Equipment.
4. Employees.

And these standards must be realized, for standards which are realized in only a minority of cases are practically useless.

The basis of manufacturing standards.—The basis for all manufacturing standards is the product. If certain standards cannot be established for the product, then it is well nigh impossible to try to establish them for materials, equipment, employees, and operations. There are very few products, however, for which standards cannot be set, even in the case of the so-called seasonal industries like the clothing trades where style counts for so much. The very existence of styles means that certain standards for the product have been established, for the styles are the standards for the product, for the season, at least. In addition, there are many elements in men's clothing, for example, for which standards can be established. Button-holes, for instance, must be made no matter what the details of the style of coat may be. There are only about five different kinds of pockets in men's coats which are used with any degree of frequency, and a definite group of standards can be established for them. The new style for the coming season is largely a regrouping of elements in a little different fashion, and it is surprising, on analysis, to find how men's garments are really made up by various groupings of standard elements.

Standards for materials.—Once standards for the product have been determined, it is possible to give attention to standards for materials and parts. As this subject has been investigated at some length, it is necessary to emphasize only two points here. In the first place, it is impossible to establish operation standards unless the material which is to be used has been standardized as to quality, and those standards maintained in actual practice. The setting of operation standards is based on the fact that materials will come to the machine in such shape that the operation can be done in the regular way. If, for example, a casting is much oversize when it is brought to a turning lathe, it may be necessary to take three cuts when two is the standard number. In a factory manufacturing electric coils, not a little trouble was experienced with the winding operation, because if the wire were not just right it would break and necessitate its splicing. Under such circumstances it is impossible to set a definite way in which the job is to be done or a definite time which it is to take.

In the second place, it is necessary to have standards for the parts which are produced as the result of the operation for which a standard is being set. If there are no quality standards for the output, then there is no way of knowing whether the operation standard is good or not. If the way of doing the work does not result in a satisfactory output, then it is not satisfactory itself and it cannot be adopted as a standard.

Equipment standards.—It is also essential to have certain standards established for equipment, more especially for the condition in which the equipment is kept than in the way of the equipment itself being of a standard design, though this latter condition helps also in the setting and maintaining of operation standards. If the machines are not kept in good repair, it is just as impossible to set operation standards as it is if the materials to be used are not up to the quality standards set for them. A slipping belt, for example, may reduce the speed of operation of the whole machine, or, in the case of a metal cutting machine, may cause it to operate by fits and starts. A dull tool will often necessitate the taking of an extra cut, and, in addition, it may turn out work which will not pass inspection.

What has been said about the machinery can be repeated in regard to the plant and the conditions in general which surround the work. A proper temperature should be maintained at all times, an adequate and even supply of light should be provided, material should be removed when completed, and a new supply brought, before that which is being worked upon is exhausted. In short, standard conditions should be established before the attempt is made to set up operation standards, and these conditions must be maintained as long as those standards are used.

Standards for the employee.—Consideration must also be given to the standards for the worker who is employed on the task. It is useless to employ either a sub-standard or super-standard workman for this purpose. The use of a sub-standard worker in connection with the setting of operation standards will result in those standards being set altogether too low, in so far as time is concerned, and seldom will the best methods be worked out with him as a subject. The super-standard worker will give good methods, but his time will be too fast in most cases to be realized by other workers, and standards should be attainable goals, not unattainable ideals.

The setting of operation standards.—The actual setting of the operation standards involves a thorough study of the shop processes. It should begin with a breaking up of the manufacturing process for any article into the several operations which are needed to produce it. This is frequently called "routing the work through the factory." It has already been pointed out in the chapter on plant layout that, in the continuous process type of plant, this routing of the work must be done as a preliminary step to the actual laying out of the factory. Once the arrangement of the machines takes effect, the routing is, so to speak, "frozen" and can be changed only with great difficulty.

In the jobbing type of factory it is necessary to establish the route for each order separately. Once this has been done for a variety of orders, it will be found comparatively easy to do so for succeeding ones, even though they are different from any which have yet passed through the shop, because of certain similarities to others which have already been routed. In this type of industry another factor must be considered at this point—the size of the order. If an order calls for only a few units, it is usually unwise to design and make many special tools, but standard tools should be employed. If the order is larger, it may be well to perform several distinct operations in succession on a turret lathe, instead of having them done separately on engine lathes; and if the quantity is sufficiently large, special tools and, in some extreme cases, special machines are justifiable. Hence, the routing is often modified according to the quantity to be turned out.

The function of time and motion studies.—Once the routing of the work is decided, it becomes necessary to study the operations themselves. It is essential to lay out a tentative method in the first instance and then carefully analyze it to see in what way it can be improved. This involves the making of time and motion studies which are really nothing more nor less than a careful analysis and measurement of the results of that analysis of the operations in hand. It is a tool to be employed in the setting of many manufacturing standards, those for materials and equipment, as well as those for operation. The first studies should be analytical and constructive for the purpose of determining the best way of storing the work, and should be followed by statistical studies for the purpose of deciding how long the operation should take.

The relation of fatigue to standards.—Before the operation standards can be set, it is necessary to give due consideration to the question of the fatigue which is involved. It should be reduced to a minimum in the first place, for the best method is almost without exception the least fatiguing one. In the second place, allowance must be made for the fatigue which cannot be avoided, for standards should be set which will result in better health for the workers, and not in their rapid exhaustion. The trade unions share this view.

Qualifications for a time study engineer.—To do the kind of work involved in the setting of operation standards requires a high grade man. He should be technically trained and understand the basic engineering subjects on which the design of machines, tools and the specification of materials depend. He should know the fundamentals of mechanics, strength of materials and kinematics so as to be able to understand the reasons for the way in which the machine operates. He should know a good bit about psychology and physiology so that he will be able to deal intelligently with the part which the workers have to play in the setting of the standards. He needs to understand cost accounting, and, particularly, the effect of burden upon the costs of production, and be able to comprehend comparative costs. Above all, he needs to have practical familiarity with the job which he is studying and for which he is setting the operation standards. When it comes to the task of recording the standards which he has established, he should be able to express them in writing clearly and succinctly, and be able to understand and use drawings in presenting his ideas.

Making standards permanent.—Once the standards have been determined, it is essential to reduce them to writing. For jobs which occur intermittently, the name given this record is commonly that of "instruction card." For routine tasks in shop or office, the name given to the same type of record is "standard practice instructions." The difference between these two sets of records is one of degree rather than a difference in object or content. Both are for the purpose of recording standard methods of procedure. The instructions which they contain must be clear and easily understood; they are specifications just as truly as are the specifications for materials, and, like material specifications, they are essential to the successful operation of the business.

Standards which are recorded in writing, but which are not used, are useless, and the cost of setting them is an absolute waste. To be really permanent and usable, it is not sufficient to record them; they must be taught to the workers who are to use them. Until the operations become really a part of the habits of work of the employee, they are not actually permanent, nor can they be relied upon in the current control of production.

To make the standards a part of the equipment of the employees, it is necessary to teach them. It is also essential to give the workers, in most cases, some incentive or stimulus, both for learning them and applying them. The variety of incentives which are available is large—competition, desire to break records, personal interest in the doing of work well, desire of advancement, fear of dismissal, increased financial gain. The latter is probably more reliable than the others, which may or may not be a good thing. It is essential to adopt some means for maintaining operation standards, once they are established, and the payment of a bonus for following instructions and accomplishing the standard quantity of work in a given time is the method most frequently employed.

Finally, it is essential to see to it that all of the standards are properly classified and symbolized so that they may be available when needed. Such a classification and symbolization should be part of a general symbolized classification of all the activities and factors with which the company works.

Conclusion.—Without standards of various kinds, including, particularly, operation standards, no factory is equipped to produce the goods which are expected of it. In some cases, such standards are mere mental conceptions, lacking definiteness and subject to reasonless change. In a well organized concern, however, they are the result of scientific investigation, are recorded in permanent form, and are used until better ones can be devised.

References for Additional Reading.

Lansburgh, R. H., "Industrial Management," Chapter XV.
Lichtner, W. D., "Time Study and Job Analysis," Chapters I-III.
Thompson, C. B., "Scientific Management," pages 242-267.

Chapter XIV

ROUTING THE WORK THROUGH THE FACTORY

Purposes of this chapter.—

1. To study the problem of routing the work through the factory.
2. To consider means for recording the routing once established.

Routing, an analysis of the direct manufacturing function.—From certain points of view the breaking up of the manufacturing processes into operations is simply a continuation of the analysis of the various activities of the business into groups of functions which form departments. The arrangement of the operations into orderly and systematic sequences is a coördination very similar in its nature to the organization of the departments. This similarity is especially noticeable in the case of the routing of work for a jobbing factory where attention must be given, not only to the sequence of operations for a single part or product, but also to the relationship of the various sequences and the operations of which they are composed. The connection between the routing of work through the shops and the functionalizing of the entire business is especially worthy of note, as it is so frequently overlooked, and as it serves to emphasize the essential unity of all the activities within a factory.

One of the first steps in routing work through the factory has already been taken when the factory activities have been organized into the form of departments. Such a grouping marks off the more conspicuously different types of operations, and hence serves as a basis for the more detailed routing which is to follow. At the same time, it should be noted that the establishment of the direct manufacturing departments depends, in some measure, at least, on a tentative routing of the work through the shops, and should not be attempted until that temporary routing has been made. It should also be noted that the routing depends to a certain extent on the selection of machinery, and the choice of equipment, in turn, is based on the operations which are to be performed. In short, the routing of work is closely interrelated with the technical problems which are involved in the question of equipment, and in the administrative problems which are raised by the task of the functionalization and organization of the company. All this is in addition to the service which it has to perform by serving as one of the bases for the setting of operation standards.

Routing both a technical and economic problem.—To be fully satisfactory, the routing must give adequate attention both to the technical problems in connection with equipment, its design, and utilization, and also to the economic phases of the matter which are encountered. No routing is desirable which does not result in the most economical production of goods. In this connection, not only must the needs of single articles be considered, but also the entire output of the factory, for what may mean economy for one order may result in losses in the case of others.

The routing of work through the factory has especial significance in the case of the continuous process type of industry, because of the dependence of the plant layout on the correct routing of the work. The effect of an error in plant layout and construction, once made, will be repeated many times and small losses many times repeated rapidly increase to large amounts. Mistakes made in the jobbing type of industry in the routing of work, while they may be individually costly, are not likely to be so serious in the long run because their effect is felt for only a short time.

Routing is based on an analysis of manufacturing processes.—The routing of the work through the shop is based on a thorough analysis of the manufacturing processes. This is more of a task than it appears at first glance, for tradition and custom have established so many practices that the way in which work is to be done may seem to be quite obvious. Experience has proved, however, that this assumption is not sound. The correct division of a process can be determined only after a thorough analysis of the work which is to be done. The first step is of the same sort that has been discussed in other connections—to determine what the needs are. The second is the decision as to the best sequence of operations to meet those needs. All this involves a consideration of the type of industry, the machinery on hand, or that may be acquired, the tools, the workers, the quantity of production per unit of time—week, month, year, etc.—and hence of the quantity which is to be worked upon at any one moment. In the continuous process type of industry this latter element is replaced by the *rate* of production, especially the peak rate.

The variety of factors to be considered.—All these various factors involve many details which demand careful study. The fact that such details often do not receive such consideration is no sign that they do not exist. It merely goes to show how large a task is left to the foremen and workers, who seldom have the time and often lack the ability to deal with them adequately. Take, for example, the question of whether it is better to mill the flats on a wood lathe face plate spindle before the taper on it has been cut. The operations themselves are not very difficult and either sequence would be perfectly possible, but the question is which order is the better. It depends in the first instance on the kinds of machines available. If a turret lathe is to be used for most or all of the turning operations, so that they can be performed without taking the part out of the machine, the problem is distinctly different from what it would be if engine lathes were the machines which it was necessary to employ, thus necessitating a change of tools or parts for the accomplishment of the turning operations. The method by which the work could be held in the several machines is another factor which would influence the decision to a considerable extent. All too often, when the routing of the work in a machine shop is left to chance, it is found that some part of the article which would be most useful for holding in the machine for the current operation has been machined off at some previous operation. The same kind of thing is encountered in the assembly of several parts to make a completed product—parts will be put together which it is necessary to separate at a subsequent operation in order to add still other units.

The effect of the quantity to be produced at one time.—In the jobbing type of industry it is essential to know what the quantity of material is which is routed through the shop on any one order. If the order calls for only a small amount, it is evidently undesirable to design and make many new tools for doing the work involved. If only two or three pieces are wanted, for example, it is much more desirable to do the work on an engine lathe than to make even a few single tools for use with the turret lathe. The use of the engine lathe, however, necessitates several distinct operations which could probably have been done with a single set-up on the turret lathe.

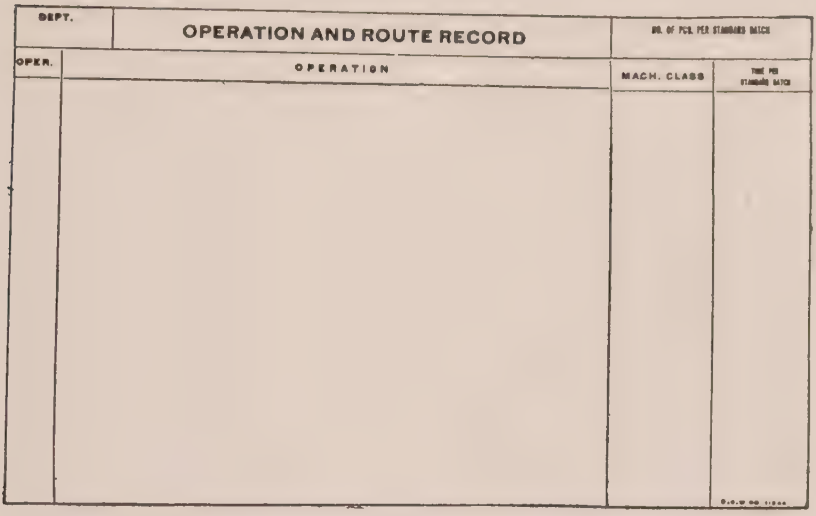
This same kind of problem is often met in the intermittent type of industry where the quantity of product called for on a single order may vary considerably from time to time. Under such circumstances it is frequently necessary to establish two, and occasionally three, standard routings for orders, the route to be chosen depending on the size of the order. If the necessary tools are made, the question of their cost will not arise in this connection, but the cost of the setting up of certain machines and the relative cost of production on various kinds of equipment will be the deciding factors. In most cases it will be found that the cost is reduced if large quantities are run at one time, but these economies are often offset by losses which may result. To run a large quantity of any one unit may mean tying up equipment which is needed for other work. It also results in heavy inventories with the accompanying large carrying charges. Deterioration often occurs in materials or parts stored for any great length of time, and obsolescence sometimes takes place due to a change in the design of the part itself, or in that of other parts with which it is assembled. The final analysis may show, therefore, that there is a mean in so far as quantities to be produced at one time are concerned, which it is desirable to establish as a basis for the standard routing, other routings being set to take care of emergencies.

Provision for alternative equipment.—There are also occasions when it is desirable to provide for the use of alternative equipment so that when it comes to the actual scheduling or dispatching of the work through the shop, a selection may be made which will often relieve current difficulties. There is no reason, for example, why one machine should lie idle, when there is work to be done which could be performed upon it, simply because the machine called for in the routing is busy at the moment. Not infrequently a large machine, perfectly capable of doing a particular task, is idle because a smaller machine is the one to which the job is routed. It is much more economical to use the larger machine than to permit such idleness, and that possibility should be indicated in the routing. Under such circumstances, however, it is necessary to see to it that the burden rate of the smaller machine is charged to the order when the work is actually done, as otherwise the job would be unnecessarily penalized because it was performed on the larger machine.

The reduction of material handling.—There is another phase of routing work through the factory which needs a little additional emphasis. It is the desirability of reducing to a minimum the amount of transportation necessary for any order going through the shop. This point is ordinarily taken care of by the layout of the factory in the case of the continuous process type of factory, but in the intermittent type, especially where the kind of product is continuously, though gradually, changing, and in the job shop, this matter deserves conscious consideration, for not infrequently a slight rearrangement of the sequence of operations will reduce the amount of handling to a marked degree.

Recording the routing of the orders.—Once the routing of the work has been standardized and established, it becomes necessary to record these standard routings in some permanent fashion, for even in the jobbing shop, although no other order exactly like the one in hand may ever again come to the factory, the routing which has been set for it is often a help in routing other somewhat similar orders. The form which it takes depends largely on the type of industry. In the continuous process type of concern, the plant layout chart or diagram will also serve as the route chart or record for the work, since the layout is the crystallization of the routing.

In the intermittent and jobbing types of industry, however, other means are necessary to record the route of the work. An example of a simple type of record for an intermittent type of company is shown in Figure 51. (Note: This figure is the reverse of Figure 49.) It may be seen here that the department, operation sequence, class of machine used, tools, and the name of the operation are shown. This is the basic information for routing the work through the shop. The form is simple and durable. A master set of such cards can be kept, so that if any card in current use is lost it can be duplicated at once. This represents about the simplest form of routing record and is adaptable to a wide variety of intermittent industries. The results of the setting of the operation standards are also shown on this form in the shape of the standard time per piece for each operation. As the principle use of the "operation record," as the route card is here called, is in scheduling production, these additional data are very helpful in any case where some quantity other than that which is standard is to be scheduled.



DEPT.

OPERATION AND ROUTE RECORD

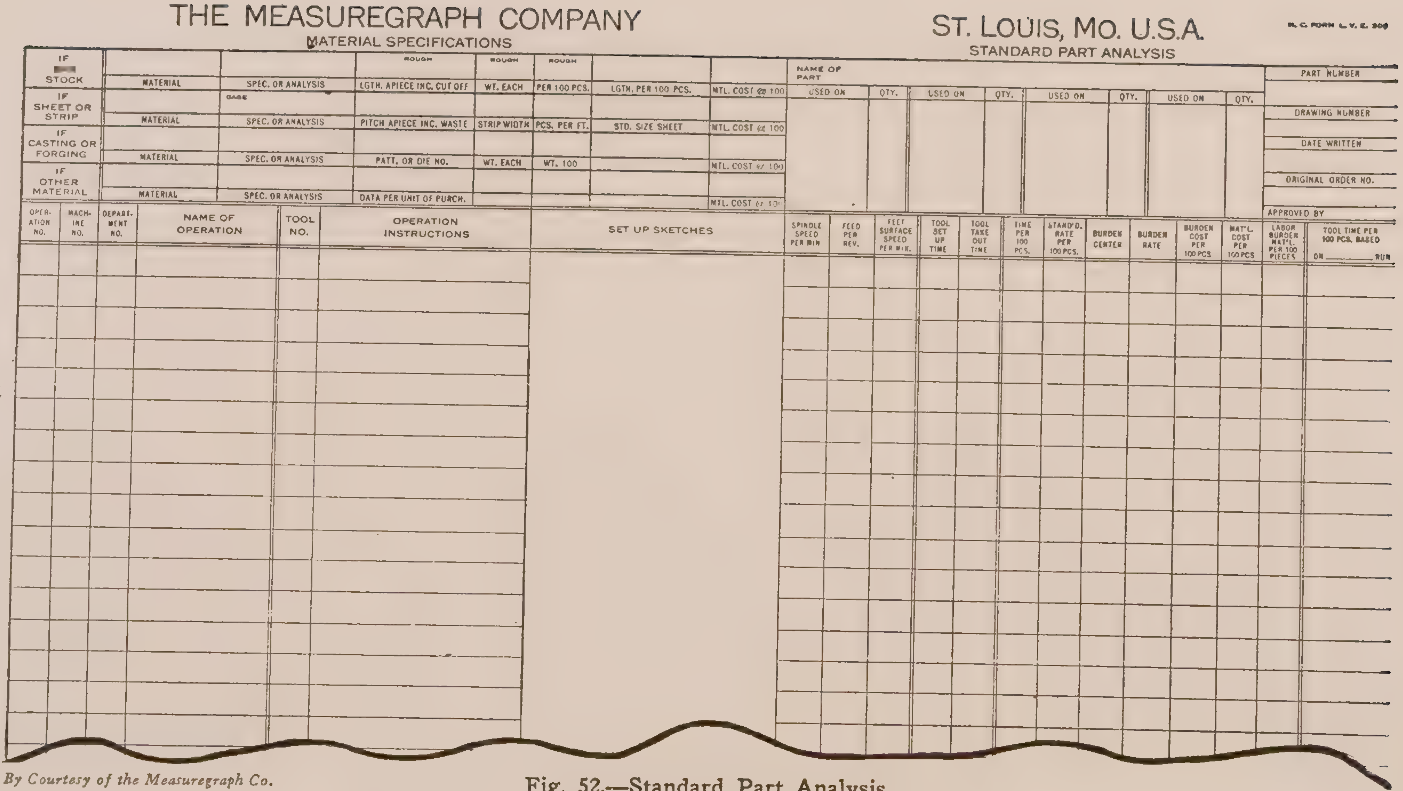
NO. OF PCS. PER STANDARD BATCH

OPER.	OPERATION	MACH. CLASS	TIME PER STANDARD BATCH

By Courtesy of the Square D Co.

Fig. 51.—Operation and Route Record.

This same idea is amplified in the standard parts analysis which is shown in Figure 52. Here, in addition to the data in regard to the sequence of operations, class of machine, etc., which belong on any route card are included most of the operation standards which are to be set after the routing has been established. This analysis includes also not a little cost data which is very helpful in the development, either of the routing or the operation standards. Data are also given in regard to the material, both the material from which the part is to be made, and the uses to which the part or assembly is to be put after it is completed. Such a record is a good deal more than a route card—it is a summary of the manufacturing standards needed for the production of the unit in question.



THE MEASUREGRAPH COMPANY

MATERIAL SPECIFICATIONS

ST. LOUIS, MO. U.S.A.

STANDARD PART ANALYSIS

M. C. FORM L. V. E. 309

IF [illegible] STOCK			ROUGH	ROUGH	ROUGH		
	MATERIAL	SPEC. OR ANALYSIS	LGTH. APIECE INC. CUT OFF	WT. EACH	PER 100 PCS.	LGTH. PER 100 PCS.	MTL. COST @ 100
IF SHEET OR STRIP		GAGE					
	MATERIAL	SPEC. OR ANALYSIS	PITCH APIECE INC. WASTE	STRIP WIDTH	PCS. PER FT.	STD. SIZE SHEET	MTL. COST @ 100
IF CASTING OR FORGING							
	MATERIAL	SPEC. OR ANALYSIS	PATT. OR DIE NO.	WT. EACH	WT. 100		MTL. COST @ 100
IF OTHER MATERIAL							
	MATERIAL	SPEC. OR ANALYSIS	DATA PER UNIT OF PURCH.				MTL. COST @ 100

NAME OF PART							
USED ON	QTY.	USED ON	QTY.	USED ON	QTY.	USED ON	QTY.

PART NUMBER

DRAWING NUMBER

DATE WRITTEN

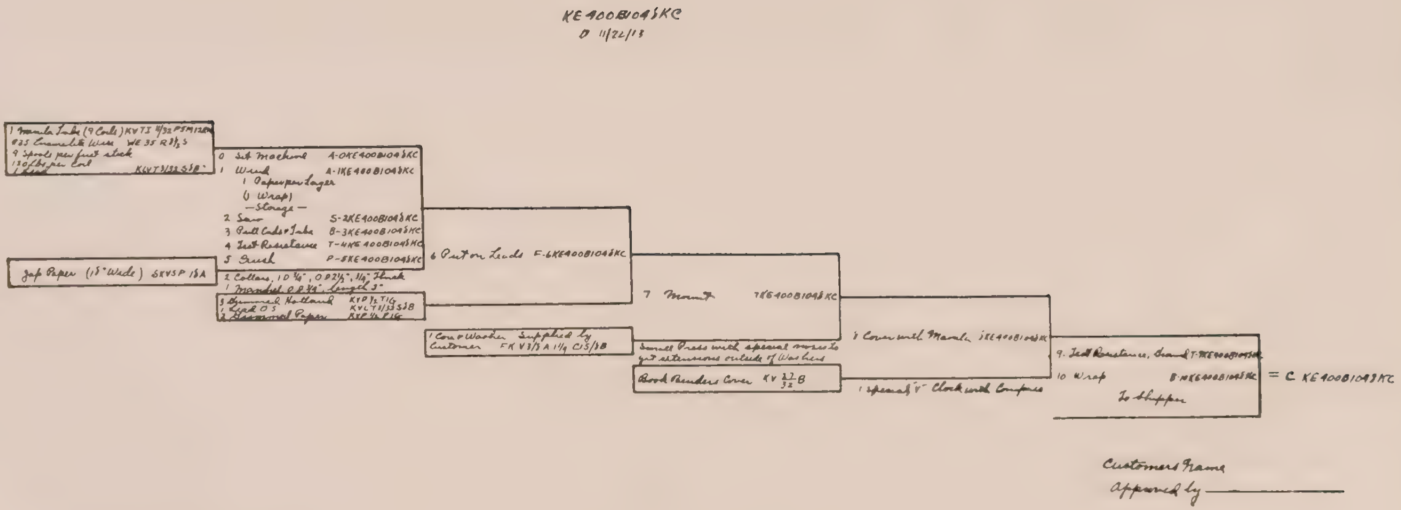
ORIGINAL ORDER NO.

APPROVED BY

OPERATION NO.	MACHINE NO.	DEPARTMENT NO.	NAME OF OPERATION	TOOL NO.	OPERATION INSTRUCTIONS	SET UP SKETCHES	SPINDLE SPEED PER MIN	FEED PER REV.	FEET SURFACE SPEED PER MIN.	TOOL SET UP TIME	TOOL TAKE OUT TIME	TIME PER 100 PCS.	STAND'D. RATE PER 100 PCS.	BURDEN CENTER	BURDEN RATE	BURDEN COST PER 100 PCS	MAT'L. COST PER 100 PCS	LABOR BURDEN MAT'L. PER 100 PIECES	TOOL TIME PER 100 PCS. BASED ON ____ RUN

By Courtesy of the Measuregraph Co.

Fig. 52.—Standard Part Analysis.


KE400B1048KC
D 11/22/13
1 Manila Tube (9 Coils) KVTI 11/32 PSM12
#35 Enamelite Wire WE 35 R 2 1/2 S
9 Spools per foot stock
130 lbs per Coil
KLVT 3/32 SSB
0 Set Machine A-0KE400B1048KC
1 Wind A-1KE400B1048KC
1 Paper per Layer
(1 Wrap)
—Storage—
2 Saw S-2KE400B1048KC
3 Pull Cords & Tube B-3KE400B1048KC
4 Test Resistance T-4KE400B1048KC
5 Brush P-5KE400B1048KC
Jap Paper (15" Wide) SKVSP 15A
2 Collars, I D 3/4", O D 2 1/2", 1/4" Thick
1 Mandrel O D 3/4", Length 3"
3 Gummed Holland KVD 1/2 T1G
1 Lead O S KVLT 3/32 SSB
2 Gummed Paper KVP 1/2 P1G
6 Put on Leads F-6KE400B1048KC
1 Core & Washer Supplied by Customer FK V 3/8 A 1 1/4 C 15/8 B
7 Mount 7KE400B1048KC
Small Press with special screws to get extensions outside of Washers
Book Binders Cover KV 37/32 B
1 Cover with Manila 1KE400B1048KC
1 special 'V' Clock with Compass
9. Test Resistance, Ground T-9KE400B1048KC
10 Wrap B-10KE400B1048KC
To Shipper
= C KE400B1048KC
Customers Name
Approved by

By Courtesy of the Acme Wire Co.

Fig. 53.—Route Chart.

This record is usually too elaborate for a jobbing concern, but is very helpful for the intermittent type of industry which is producing a relatively complex product.

Still another form for recording the routing of the work is shown in Figure 53. This form presents the routing in diagrammatic shape and is called a "route chart." The sequence of operations is shown very clearly and the tools and materials as well. A further modification of this kind of chart, in which the length of lines between operations show the comparative length of time which the several operations take, is sometimes made after the operation standards have been established. The great advantage of this type of routing record is that it shows the route of the order graphically and gives a more concrete view of the course to be followed than does the tabular form. It is a method selected from the experience of a jobbing type of concern where it has given great satisfaction.

In dealing with the problem of routing work through the factory, it is important to remember that the process involved is essentially analytical, a breaking up of the fabrication of the unit into distinct operations in order to facilitate the setting of operation standards, the scheduling of production, and the reduction of the cost of fabrication. The results should be standard routes for the orders to follow through the shops. Difficult as the setting of routes in the jobbing type of industry may appear, it is just here that they are most needed. At all times the standard routing of the work should be thought of and treated as one of the basic manufacturing standards.

References for Additional Reading.

Carpenter, C. N., "Increasing Production, Decreasing Costs," Chapter XIII.

Day, C., "Industrial Plants," Chapter VII.

"Library of Factory Management," Vol. V, Chapter III.

CHAPTER XV

MAKING TIME AND MOTION STUDIES

Purposes of this chapter.—

1. To consider the purposes of time and motion study.
2. To study the prerequisites to a time and motion study.
3. To outline the making of a time and motion study.

The making of a time and motion study is simply one step in the direction of setting manufacturing standards in general, and operation standards in particular. It is not a cure-all for every trouble which is encountered in the factory, it is not an end in itself, but it is a useful and important tool for the accomplishing of some necessary tasks involved in the control of production. Fundamentally, time and motion study involves a study of the motions needed to perform an operation and the time which these motions take. It is really a kind of analysis plus a definite measurement of the results of that analysis in terms of at least one unit, time. It is a means of providing the management with some much needed information concerning what goes on in the shops, and, on the basis of the data so obtained, changes may be made which should result in improvements. To determine whether they are needed, additional time and motion studies are necessary by means of which the worth of the changes can be evaluated. Other improvements, not seen at first, may appear as the result of such studies, and they should be made and tested in the same fashion. Such time and motion studies are often called "analytical." When the best method—as far as can be seen—has at last been determined, it is then necessary to make what has been termed "constructive" time studies for the purpose of deciding how much time the accepted method should take.

Standards affected by time and motion studies.—In making time and motion studies, many other matters beside the immediate operation will necessarily be investigated, and many of the changes will be needed outside of details in the control of workmen and even outside of the shop itself. Materials, both as to design and supply, the machine and its condition, the design and material of tools, the means of applying power, the methods of production control, purchasing, maintenance, accounting, and even of sales, may require alteration because of the facts uncovered by time and motion study. If the study is carefully and intelligently made, the results attained are often more far reaching than is commonly realized.

It should be appreciated, however, that time and motion studies in themselves are not constructive. They do not accomplish any improvements or directly result in better methods. They are simply a source of supply of data on the basis of which action can be taken. Instead of working in the dark, the factory executive who has had time and motion studies made, can act on a basis of fairly definitely ascertained facts. In this respect, such studies are like the reports of current operations which enable a manager to plan the future intelligently because he knows what has taken place in the immediate past.

The worker's relations to time and motion studies.—The nature of time and motion studies needs to be kept clearly in mind in dealing with another phase of factory administration —the relation of the employees to such studies. Probably the majority of the workers in this country who have ever heard of this type of study are opposed to it, and this feeling finds concrete expression in the almost universal opposition of organized labor to it, and in organized labor's many attempts to forbid time and motion studies by legislative action. Nor is this sentiment on the part of the workers without considerable apparent foundation. All too frequently as the result of such studies, they have found themselves speeded up to an almost impossible pace, then wages cut until it is only by exhausting exertion that they have been able to gain a living wage, and their condition in general changed very much for the worse. It is not surprising, therefore, that they are often heartily opposed to such studies.

Their opposition, however, though justified and understandable in the light of these facts, is misdirected. Time and motion studies are simply a tool, and have no more moral qualities than a machine. It is just as illogical to oppose time and motion studies now as it was to oppose the introduction of machinery at the time of the industrial revolution, though there is no question but what many workers then suffered severely because of the changes which were taking place. The trouble now, as at that time, lies not with the mechanism in question, but with the men who use the mechanism, and with their morals. If they have a proper sense of their social responsibility, then the employment of machinery, or the use of time and motion studies, does not bring unfortunate results to the workers, but rather tends to better their condition, especially over a period of time. This can be seen to be true in the long run in the case of machinery, and in numerous instances it has been proved to be so also in the case of time and motion studies. The opposition of the workers, therefore, should be against the *abuse* and not *use* of such studies, and against those executives who fail to realize their responsibilities in connection with the possession of a tool which has the possibility of doing harm to others. In their opposition to abuse, the workers can be very appropriately supported by those executives who do appreciate the social significance of their position.

Preliminaries to time and motion studies.—Before attempting to make a time and motion study, there are many details which must receive adequate consideration. It is essential, in the first place, that proper standards be set for materials, equipment, and workers, and that these standards be maintained. This is the reason why a great deal of preliminary work should be done in a shop before any attempt is made to begin time and motion studies.

Standards for material.—Material is one of the first points which demands consideration in this connection. Definite standards must be set in the first place and enforced in the second place. If steel bar, for example, of varying degrees of hardness comes to the machine, the time needed to machine it will fluctuate over wide limits; the depth of cut, feet, and speed cannot be maintained constant; and the whole operation in fact must be changed simply because the material either has not been standardized as to hardness, or the standard has not been maintained.

It is also of prime importance to have the delivery of material under control. While it may be possible to make time studies with a selected lot of material carefully guided to the spot where it is to be used, it is hardly worth while to make them, for it would be quite impossible to put them into practice. To be of practical use, time studies for setting operation standards must be based on conditions as they are in the shop. Hence, the delivery of material must be assured before such studies can be made and applied. Under the best of control, delays will occur from time to time, and allowance should be made for them. They ought, therefore, to receive consideration when the time and motion study is being carried on. Under some circumstances, of course, it is desirable to make a time study of the amount of time which is lost, due to materials being delayed in transit, but such studies should be undertaken independently, and not as a part of those on which operation standards are to depend.

Standards for equipment.—It is also necessary to make sure that the equipment which is to be used is up to the standard of condition which it is proposed to maintain as a regular matter.

The belting used in the transmission of power from the counter shaft to the machine is an element of equipment which is commonly found and demands especial consideration, because of the effect which it has on the setting and maintaining of manufacturing standards. The belts should be "right" before any time and motion studies on the machine are commenced. By "right" is meant that they should be of the proper material and adequate width, that joints should be correctly spliced, and last and most important of all, that their tension should be correct. This does not mean that the tension can be increased to the limit. To do so brings unnecessary stresses on the belt, harmful friction on the bearings, and increased maintenance without any proportional increase in power delivered. On the other hand, the belt must not be too loose, as otherwise there will be much slipping and an adequate supply of power will not be carried to the machine. The proper mean must be ascertained and established as the standard, and in so doing, time studies for this purpose may frequently be employed. These studies also should be preliminary to those used in setting the operation standards.

Tools, especially cutting tools, are also an element for which standards must be established before time and motion studies for the setting of operation standards are attempted. It is quite impossible to determine the length of time which a job should take if there is marked variation in the quality of the tools employed. The depth of cut, feed, and speed will all be changed if a high carbon tool is used to replace an alloy steel tool, and there are also marked differences in the effect of the various grades of tool steels within these two principal classes.

It is necessary to add to this problem the determination of the proper cutting and clearance angles, the amount of "rake," etc., which it is necessary for the tool to possess. The setting of these tool standards is a long and arduous process and involves the study of many other factors such as the depth of cut, feed, speed, methods of cooling the tool, etc. A great deal of research has already been carried on along these lines and the results are now available for the use of those who are confronted with the problem of setting manufacturing standards. Time studies are necessary in making the needed analyses here as in the other cases already noted.

The late Mr. F. W. Taylor was a pioneer in this field. Associated with Mr. Maunsel White he developed the Taylor-White tool steel, one of the first of the modern tool steels, and the results of his research is incorporated in his book, "On the Art of Cutting Metals."

It has been pointed out that it is often desirable to make special time studies in connection with the setting of standards for materials and equipment and their control. It should also be noted that a great deal of information is often obtained concerning these factors in the course of the making of the ordinary time and motion studies. In fact, one of the benefits to be obtained from such studies is the information that conditions are not right, and some indication, at least, of where the trouble is. Once a difficulty is located, the first step has been taken towards its elimination.

The type of men needed for making time studies.—One of the important preliminaries to the making of a time study is the selection of the persons who are to have a part in it. In general, there are two—the man who does the work and the man who makes the study. It has already been noted that the normal or "standard" worker is the one who is wanted as the subject for the time study, and that specifications for such a worker should be drawn up. There is a good deal more to the selection of a workman for this purpose, however, than obtaining a man who is about a certain height, and weight, with approximately so much knowledge of the machine and work in question, and who is sober and trustworthy. All these specifications are essential, but they are not all. It is of fundamental importance to select a man who is willing to have a time and motion study made of his work. It is a basic rule never to try to make a study of an unwilling subject. The results of a study on a rebellious workman are never worth the trouble, and the ill-feeling and rancor engendered in the man and his associates will more than offset any advantages to be gained from the study. There is no excuse, also, for making time and motion studies on the sly.

In addition, it is necessary to choose a workman who is competent and who apparently has worked out the best method for accomplishing the task. He should be better than the average worker, but not an excessively fast worker. Care should be taken not to select a man who, because of certain peculiar personal characteristics, is able to do the work much faster than the normal first-class man. Such men are not infrequently found, and they are often, though not always, among the most productive of the working force, but they are not good subjects for time and motion studies, as standards set on the basis of their work can seldom be applied to current tasks. Of course, any motions which they may employ which are an improvement over those commonly used should be adopted and taught to the other workers as far as possible. Usually, however, such workers do not utilize any better methods, but their high output is due to their abnormally fast reaction time, deftness of touch, extreme manual dexterity, etc. The effort should be made to obtain a good, somewhat better than the average, workman as a subject.

The requirements for a time study engineer.—It is also important to choose wisely the man who is to make the study. For a task of this kind, moral qualities of a high order are essential. The time study engineer must be absolutely honest with his work, with the man he is studying, and with the company that employs him. There are few ways of checking him up, except by doing his work over again. This should be done at first, not only to check his honesty, but to verify his ability and good judgment. He should be tactful with the workers, a good mixer, and yet able to maintain his dignity among them. He should have good training in the basic engineering subjects and ought to possess much experience with the type of work which he is studying and a certain degree of capability for performing the task for which he is setting the standards. Often workers are skeptical of such standards, especially of the possibility of doing the work in the time allowed, and nothing convinces them like seeing the man who set the standard demonstrate its practicability.

Above all, he needs to be possessed of both an analytical and synthetical type of mind. That is, he should be of the sort which wants to get at the facts in all their detail and know all about them, but, having done that, wants to put all the parts together again so that the result is better than the original. All this calls for not a little inventive ability and a combination of qualities which is not always to be readily found. It is often much easier to find such a type in the shop than is commonly supposed, and if a man has such qualities and the requisite character, it is much better to select him and give him any needed training than it is to try to create native ability and develop character where they do not already exist.

The location of the place of making the time study.—There is still another preliminary question which must be answered before the actual time and motion study is started—the place where the study is to be made. In general, the choice lies between two locations—the shop where the work is to be done regularly and a laboratory equipped for the purpose. It might seem as though the decision were rather obvious. The shop is the place where the work is to be done, and hence it is the place in which to make the study. Any failures or shortcomings which are likely to be encountered when the standards are being applied will probably be met and receive due consideration, either being eliminated or taken into consideration. The tools, the machine, the surroundings are all normal, and hence more satisfactory results can be obtained here than in a special laboratory where conditions are abnormal.

In the majority of cases this is all true, and the shop is the best place for making time and motion studies because conditions are as they are, and it is with such conditions—good, bad, or indifferent, as they may be—that the time study engineer must contend. There are circumstances, however, when it is better to make use of the laboratory. If, for example, it is desired to decide on what kind of steel is best adapted to certain operations, what the shape of the tool should be, what the most satisfactory speeds and feeds are, what the proper tension in the belt should be, etc., then it is usually more satisfactory to make the necessary time studies in a laboratory where conditions can be controlled much more closely than is possible in the shop.

If there is much opposition on the part of the workers to the making of time and motion studies, it is often desirable to make at least the first of them in a laboratory where the worker will be less subject to pressure of one kind or another on the part of his fellows and where there will be little danger of the equipment being tampered with when not in use. These are the two principal reasons for making time and motion studies in a laboratory; under most other conditions, it is better to make them in the shop.

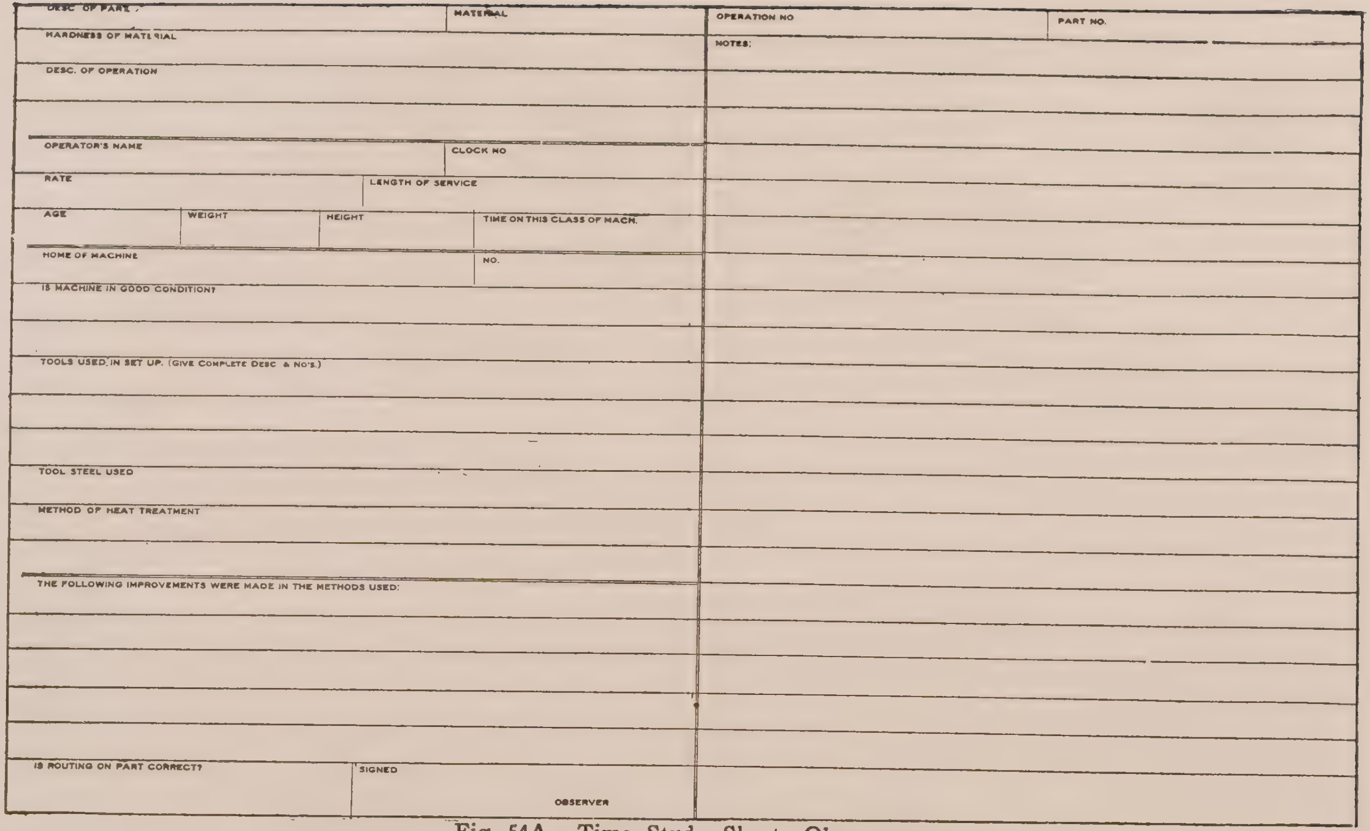
Methods of making time and motion studies.—There are two outstanding methods at the present time for making time studies. One of them is the traditional method first brought to popular attention by the late F. W. Taylor—the observer with the stop watch—and the second which received its greatest development at the hands of Mrs. F. B. Gilbreth and the late Mr. F. B. Gilbreth—the use of the motion picture machine.

There is little question but that the latter will be employed to an increasing extent in the future, but at present its use has been limited to the hands of a comparatively few specialists. There is no doubt but that it has certain very distinct advantages, among them permanency of record, which allows the motions to be studied many times at various rate of speed later, a record of *all* that takes place within the range of the camera, a mechanical accuracy which it is not possible for a human being to duplicate, and particularly, if a stereoscopic motion picture is made, a clear visualization of the relation of the various motions to each other.

On the other hand, there are certain disadvantages attached to the use of the motion picture, not the least of which is the expense. To make a really careful study of an operation, a number of complete cycles must be taken and if the operations are of any appreciable length, that means a good many feet of film. It involves the use of specialized and expensive apparatus and necessitates the training of the observer in the methods of manipulating a movie camera and in the art of taking good motion pictures, not so much from the artistic point of view, it is true, but from the standpoint of really recording what takes place. It is often difficult to provide satisfactory light, and the use of such a machine creates a very different atmosphere around the worker from that to which he is accustomed. For the present, at least, it is likely that the method most used will be that of the observer with a stop watch.

The analysis of operation into sub-operations.—The first step in the actual making of a time and motion study by this latter method is to break the operation up into sub-operations. Here the knowledge and good judgment of the time study engineer is called upon, for the ease with which the study may be made, and the utility of the results attained, depend largely on the skill with which this analysis is made. The sub-operations should be such as will most aid in the study of the process involved and the setting of the operation standards. There are two suggestions which may be offered to guide the judgment of the engineer in this matter. In the first place, there is no use in separating sub-operations to such an extent that it is impossible to observe them correctly. It is useless in most cases to try to time operations which take less than two seconds or 5/100 of a minute, for the probable error is so great as to vitiate the results. It is also essential to split an operation at points which can be easily observed. It is equally useless to try to time sub-operations when the dividing line between them is so hazy that it is impossible to note it clearly twice in succession. Unless the observer has had some little experience with the kind of operation at hand, he must expect to make several analyses before he gets one which is satisfactory for the study, even of the operation as it actually is. Of course, as the method is improved and motions are eliminated, new subdivisions must be made. In preparing his first analysis, the time study engineer is likely to find a number of changes desirable, the need for which is perfectly evident, and these should be made before he completes his first draft.

The importance of determining correct sub-operations.—One point in particular, which is frequently overlooked, deserves emphasis in connection with the division of an operation into sub-operations. Where there are many similar jobs to



DESC. OF PART

MATERIAL

OPERATION NO

PART NO.

HARDNESS OF MATERIAL

NOTES:

DESC. OF OPERATION

OPERATOR'S NAME

CLOCK NO

RATE

LENGTH OF SERVICE

AGE

WEIGHT

HEIGHT

TIME ON THIS CLASS OF MACH.

HOME OF MACHINE

NO.

IS MACHINE IN GOOD CONDITION?

TOOLS USED IN SET UP. (GIVE COMPLETE DESC. & NO'S.)

TOOL STEEL USED

METHOD OF HEAT TREATMENT

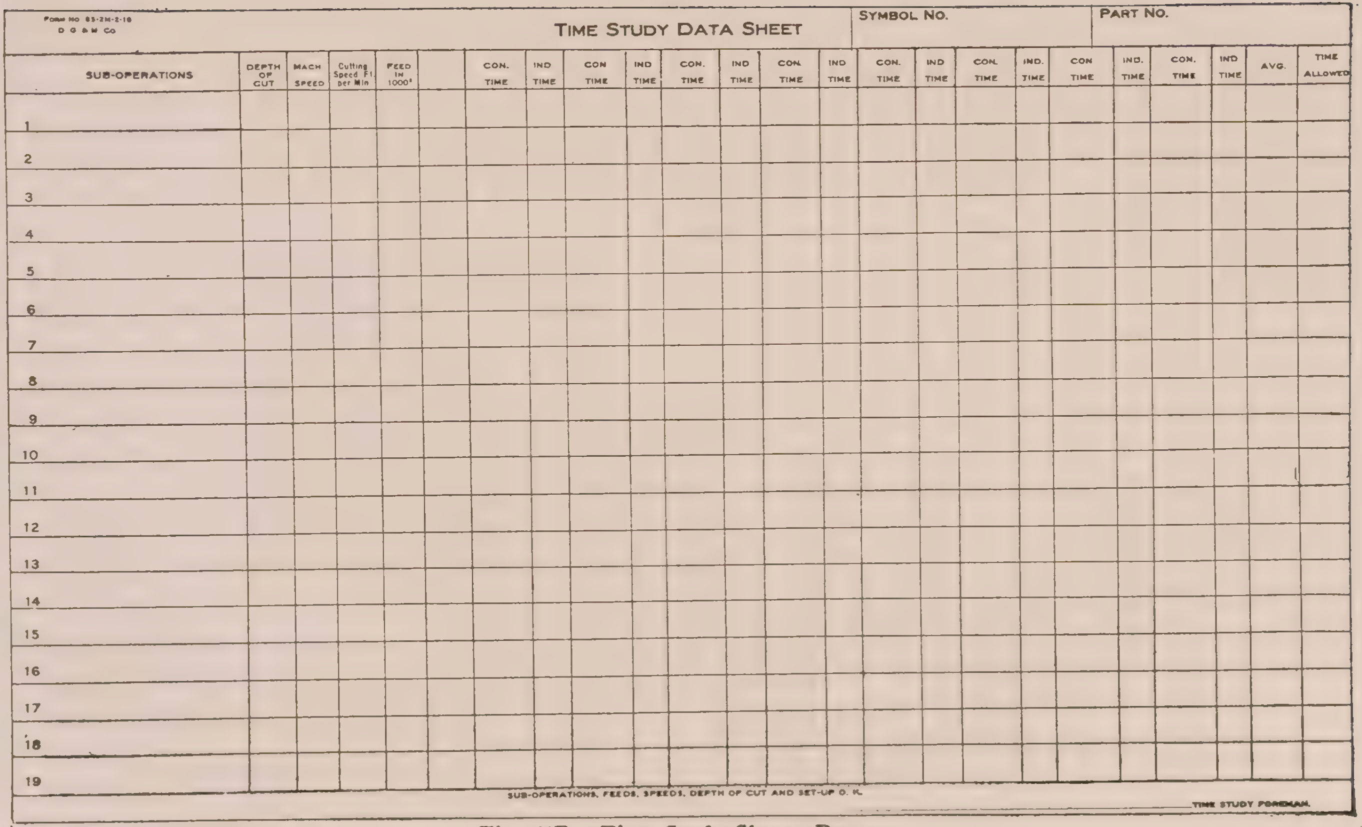
THE FOLLOWING IMPROVEMENTS WERE MADE IN THE METHODS USED:

IS ROUTING ON PART CORRECT?

SIGNED

OBSERVER

Fig. 54A.—Time Study Sheet—Obverse.



Form No 83-2M-2-18
D G & M Co

TIME STUDY DATA SHEET

SYMBOL NO.

PART NO.

SUB-OPERATIONS	DEPTH OF CUT	MACH SPEED	Cutting Speed Ft. per Min	FEED IN 1000"		CON. TIME	IND TIME	CON TIME	IND TIME	CON. TIME	IND TIME	CON. TIME	IND TIME	CON. TIME	IND TIME	CON. TIME	IND. TIME	CON TIME	IND. TIME	CON. TIME	IND TIME	AVG.	TIME ALLOWED
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							
12																							
13																							
14																							
15																							
16																							
17																							
18																							
19																							

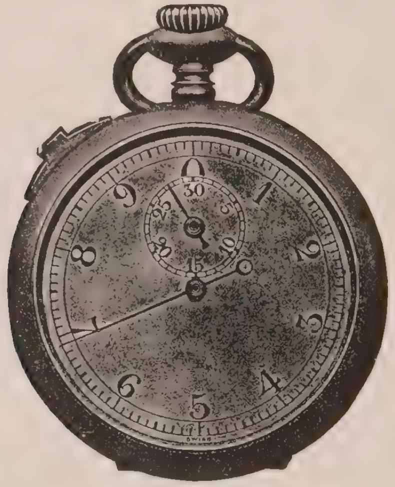
SUB-OPERATIONS, FEEDS, SPEEDS, DEPTH OF CUT AND SET-UP O. K.

_______________ TIME STUDY FOREMAN.

Fig. 54B.—Time Study Sheet—Reverse.

be done, it will be found highly desirable to divide all operations into the same sub-operations, as far as it is possible. Such a procedure permits the checking of a time study by the results of other time studies for the same kind of operations. In many cases, after sufficient unit time studies have been made on the same basis, it becomes possible to set operation standards without making any time study at all, simply on the basis of information obtained from previous time studies. This possibility has special importance in the case of the jobbing type of company where the cost of making time studies for all jobs would be prohibitive, but which can well afford to make sufficient unit time studies to serve as a basis for operation standards for almost any work which may come to them.

A time study sheet.—The sub-operations should be listed on a time study sheet, an example of which is shown in Figure 54. It will also be noted that there are spaces left for recording the depth of cut, speed, and feed. All such data should be entered before any observations are made. On the opposite side of the sheet it will be seen that spaces are left for a variety of information which is most helpful when it comes to the actual setting of the operation standard. The time study engineer should also equip himself with a time study watch, an example of which is shown in Figure 55. The most convenient type of watch is graduated to hundredths of a minute, in-



By Courtesy of Mortimer J. Silberberg Co.

Fig. 55.—Time Study Watch.

stead of to seconds, as this graduation simplifies later computations. Such a watch is started and may be stopped without being thrown back to zero, by means of the slide at the side. This is sometimes useful for the elimination of time for accidents, etc., which should enter into the standard in the form of an allowance, and not as a direct part of the net standard itself. The time study engineer should also be provided with a board on which both the time study sheet and the watch can be conveniently mounted.

The position of the observer.—The best place for the observer to stand in most cases is at the side and somewhat back of the worker. This enables him to get a clear vision of the work, and at the same time not be in the way of the operation or in the direct line of vision of the workman, who is likely to be distracted, if, every time he looks, he inevitably sees the observer watching him.

The recording of continuous times.—It is desirable in making a time study, to record what is called the "continuous" times, that is, the exact reading on the watch, and calculate the elapsed time for each sub-operation later. To try to record the elapsed time as the study is made involves too much mental computation on the part of the observer with a consequent liability to make mistakes. Such a method also provides no means for checking the accuracy of the record, while, if continuous times are noted, the sum of the calculated elapsed time should equal the last time entered on the sheet. If it does not, there has been some error in the computation and the figures must be checked till the error is found.

As the observer records the times, he must study the motions which the workman makes and be on the lookout to see which ones, if any, can be eliminated or combined with others to advantage. Such details as the direction of movement, distance moved, path followed, weight and bulk of article handled, and the facility with which it may be held, should all be studied. It will often be found that some simple and relatively obvious changes will simplify the operation very materially.

Setting the operation standards.—Once the time study is made, a single time study may involve from 3 or 4 to 100 observations of complete cycles of sub-operations. The time study engineer should calculate the elapsed times for the sub-operations, and then study the results in the light of any written or mental notes which he may have taken, especially those in regard to tools, materials, the machine, the worker, surrounding conditions, and difficulties encountered. He is very likely to find that certain changes are necessary, and he should outline what they are and request that they be made, going to the proper person who has authority over the factor in question. It should be remembered that the time study engineer does not have authority to *order* changes in the shop, but can merely recommend them. Of course, if his recommendations are not accepted, he can take the matter to the production engineer and he, in turn, can take it to the factory manager. The reason for the failure on the part of the person to accept the suggestion can then be determined. There may be some good reason for overruling the recommendation, or there may not be, and the proper authority will then issue instructions that it be accepted and put into effect. If the proper spirit exists in the shop, there will be few occasions when any such course of action will be necessary.

After changes are made, sufficient time must be given the workman to become familiar with the new method, tool, or whatever is different, and then another time and motion study must be made and analyzed as before. If this is the beginning of the time studies on this type of operation, it may be necessary to repeat the procedure several times before what seems to be the best method is determined. It not infrequently occurs that it is desirable to stop making the time studies for the purpose of setting operation standards, until such matters as the proper design of the tools, or the correct specification of the material, or the dimension limits of the product, have been decided. Finally, however, the analytical time studies are completed and the constructive time studies are begun.

Constructive times studies.—The latter are based on the assumption that the best method has been determined and that what remains to be done is to collect adequate data for setting a standard time for the operation. The times are recorded in the same way as before and the unit times are calculated as in the previous instances. Then, however, comes the problem of determining the standard time. There are numerous methods to be followed in making these computations. None of them is thoroughly scientific, and all are more or less empirical. Many of them have given excellent satisfaction in use, and that is the principal end desired. The following method is one of the best, but it should not be assumed that it is of universal applicability, nor that there are not others equally as good and perhaps better. It has stood the test of practical use under a wide variety of circumstances, however.

Calculating the standard time.—After the unit times for ten or more observations are calculated, any unit times which are unusually long or short are rejected, as they probably represent either errors in recording the times or peculiarities in the doing of that particular sub-operation which are not likely to be repeated. Of the unit times which are left, the average of the *two shortest* for each sub-operation is obtained and also the average of *all* of the unit times for the same sub-operation. The mean between these two averages is calculated and the sum of these means for all the sub-operations making up a complete cycle is taken as the *net* standard time for the operation.

Allowances.—To the net standard time, three allowances are usually added, one for unforeseen contingencies—tool trouble, material trouble, etc.—a second for personal necessities, and a third for fatigue. The allowance for the first can be obtained from "over all" time studies continued over a fairly long period of time—several days—which will give a fairly definite idea of the amount and kind of trouble encountered under standard conditions. The allowance for personal necessities can usually be estimated on a per diem basis and reduced to a percentage to be applied to all jobs alike. The allowance for fatigue is a more difficult problem and is discussed at some length in the following chapter.

These allowances, when added to the net standard time, give the standard which is commonly used as the standard operation time. It is recorded, along with the instructions for doing the job on an instruction card and so becomes a basis for planning, scheduling, and dispatching the work through the factory.

Conclusion.—It will be seen from the foregoing discussion that the making of a time and motion study is the application of the experimental method of pure science to the problems of factory control. It is evident, however, that, as commonly carried on, such studies do not have the accuracy of pure science—first because there are so many variables involved, especially in so far as the human beings who have a part in it are concerned, and secondly, because, although greater accuracy might be attained, the cost would be so great as not to be justified by the results. This does not mean that progress is not being made in the direction of increased accuracy, but it does imply that too much cannot be expected of time and motion studies as they are at present made. On the other hand, their services to industry have been many and great, and because they are not perfect either in their method or their results is no reason at all for discarding them or failing to make use of them. They are one of the important means for building up the "science" of manufacturing, on the control of which the "art" of administration is based.

References for Additional Reading.

Basset and Heywood, "Production Engineering and Cost Keeping," Chapters X, XIII, XIV.

Lichtner, W. O., 'Time Study and Job Analysis," Chapters IX-XI.

Merrick, D. V., "Time Studies as a Basis for Rate Setting," Chapters II-IV, VI-XI.

Van Deventer, J. H., "Planning Production for Profit," pages 109-161.

Chapter XVI

FATIGUE AND ITS RELATION TO MANUFACTURING STANDARDS

Purposes of this chapter.—

1. To study the nature of fatigue.
2. To investigate ways of reducing fatigue.
3. To consider the effect of fatigue on the setting of manufacturing standards.

An important factor in the establishment and maintenance of operation standards is fatigue on the part of the worker. In calculating the amount of time which should be set for an operation, it is necessary to make an allowance for fatigue. This, perhaps, is the commonest way of dealing with the problem of fatigue in so far as it concerns manufacturing standards. But it is not the only method, and even when it is the best way of meeting the difficulty, the question as to how much allowance to make still remains to be answered. The first step to take in the solution of this problem is to determine, if possible, what the nature of fatigue is.

The nature of fatigue.—Physiologists and psychologists are not all in accord as to what fatigue actually is, but there is sufficient consensus of opinion to permit some generalized statements in regard to it. Most scientists agree that fatigue is the using up of the energy-giving material, called glycogen, in the body, and the accumulation of the wastes which result from mental or physical activities. These wastes, which cause certain reactions to take place which break down and destroy some of the cellular tissues, are carried away by the blood. So long as the wastes are removed as fast as they are produced, fatigue does not set in. Fatigue, then, is caused, partly at least, by the clogging of the circulatory systems with wastes. In this respect it is like the slowing of a clock because of an accumulation of dirt on the moving parts. During a period of rest the excess wastes are removed and other chemical reactions take place which restore the system to its previous capacity for activity.

If exertion is recommenced too soon after fatigue has been experienced, fatigue will become progressively more intense, and increase much more rapidly in proportion than the amount of the exertion, and hence in a like ratio reduce the capacity for activity. It is this reduction in the capacity to do work which has special significance for the production engineer, for it affects his problem of setting operation standards. Of course it is impossible to do work without fatigue, for any exertion produces it. The principal problem is to reduce the amount of fatigue to a minimum, and then set such standards that the maximum output can be obtained without resulting in such an accumulation of fatigue as to be harmful to the worker.

The common interest of worker and employer in fatigue.—The interests of the worker and the employer are identical. As large an output as possible is, in general, desired; for this, in most cases, results in a larger available income to be divided among them. The workman wishes to do nothing to injure his health as it is most important to his welfare and happiness, and the interest of the employer coincides with that of the workers at this point—although many of them do not recognize it—because once a worker has spent some time with a particular concern, he acquires a knowledge of methods and conditions which gives him a certain value to the company, even in spite of what may be obvious faults. There are few tasks in any business which do not require a certain amount of training and for which experience cannot better a man. In many instances, also, the current work to be done is seriously hindered if an employee does not come regularly to his task; and sickness or any cause for absence, which is induced by overfatigue, should be avoided, if possible. Not only does unearned burden accumulate on a machine left idle when the workman fails to appear, but schedules are upset and many indirect losses result. Employers should recognize this side of the question, for it is much to their benefit to give adequate attention to measures which will prevent harmful fatigue of their workers.

Fatigue from long hours reduces total output.—During the World War, the British Ministry of Munitions had some interesting experiences with the effect of fatigue on output, and it was found that, not only was the rate of production per hour reduced by long hours of work and the accompanying fatigue, but the actual total output was also cut. It was a direct and positive benefit, in so far as total output was concerned, to shorten the length of the working day and so reduce the amount of fatigue. The most productive length of day for the various kinds of work involved varying amounts of fatigue could be found only by experiment. These experiences simply served to reinforce the results of other experiments which have been made along this line.

Fatigue reduces quality of product.—Not only does fatigue result in a lessened capacity for doing work, but it also results in a lower quality of work accomplished. As fatigue increases, more and more mistakes are made. This factor also has considerable practical importance for the factory executive, for the maintenance of quality in the goods produced is one of the essentials of satisfactory factory operation and low cost of production.

In so far as the worker himself is concerned, fatigue means, in addition to lessened output of lower quality—all of which may directly affect his earnings—decreased satisfaction with his work and an increase in the desire for a change whether it betters him or not.

The way in which the results of fatigue are experienced.—The amount of fatigue which is experienced in the performance of a certain task depends principally on three factors: (1) the kind of work to be done, (2) the surrounding conditions, and (3) the worker. The production engineer, in the setting of his manufacturing standards, must deal with all three.

It is self-evident that there is more fatigue involved in the handling of pig-iron all day than in copying figures from one record to another, as the assistant bookkeeper does. It is not so evident that the designing engineer, sitting at his desk or drawing board all day developing the design of a new machine, may be quite as much and even more fatigued by his day's work than the bricklayer. In other words, there is both mental and physical fatigue to be considered, and mental exertion may be quite as fatiguing as physical activity. Of course, in most cases, a job involves both kinds, for the bricklayer must use a certain minimum amount of intelligence on even the simplest kind of a back wall, while the designing engineer must make use of his pencil.

Classes of shop operation from the standpoint of fatigue.—In so far as most shop work is concerned, the general statement may be made that more fatigue is involved in those operations where the power to propel the tool, as well as the skill to guide it, is furnished by the workman, and that the more the machine has to do with moving and guiding either the tool or the material the less the fatigue which results to the worker. There are usually two reasons for this, both of which ordinarily are combined in practice. When the machine does most of the work, as in the case of the automatic lathe, less activity is necessary on the part of the worker in the first place, and more opportunity for rest and recuperation is available in the second place. Practical experience bears this out, for, in the case of the machinist who has charge of a bank of automatics, no allowance for fatigue is necessary in most instances, while, in the case of the man doing hand-filing and fitting at a bench, or hand assembling work, 50 per cent, 60 per cent, 75 per cent, and, in extreme cases, even 100 per cent of the net standard time must be allowed for fatigue.

Elements of the work which affect fatigue.—Due consideration must also be given such elements as the weight of the material to be handled and the distance moved, pull which must be exerted (as on the capstan of a turret lathe), the rapidity of operation of the machinery which is being controlled, the speed with which that control must be exercised, and the quality of the product turned out. The greater the exertion caused by any of these, the greater the resulting fatigue.

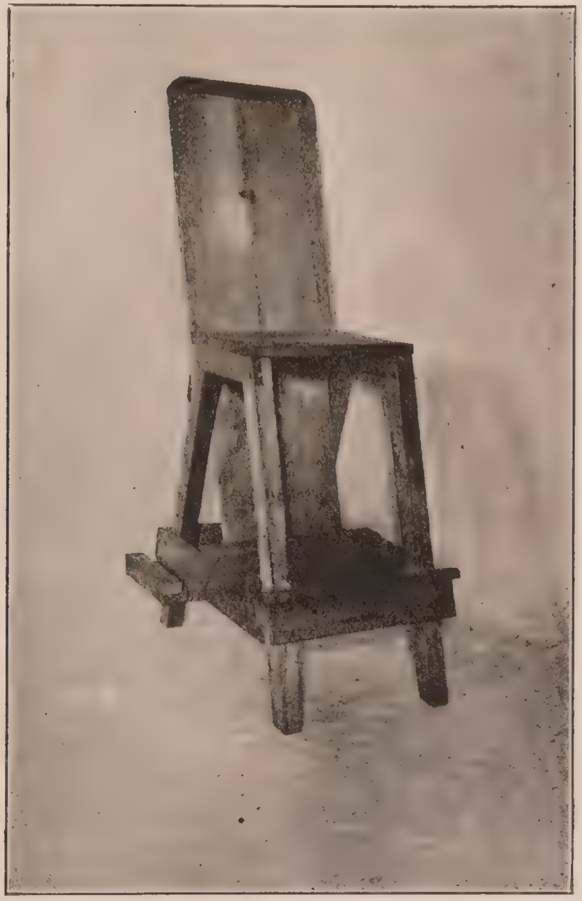
The surrounding conditions are very important factors in dealing with the problem of fatigue. Vibration of the machinery which is conveyed directly or indirectly to the worker, glare from sunlight or artificial light, lack of adequate light, badly placed material so that unnecessary efforts are needed to get it, inadequate means for disposing of it after the work upon it has been done, lack of proper ventilation, unnecessary dust and fumes, inadequate provision for chairs, stools or other means for sitting while at work or between operations—these and many other elements of the surrounding conditions all add to the fatigue of the worker, and the contrary state of affairs tends to reduce it. These are points which demand careful attention on the part of the production engineer, for they all affect the operation standards which he is engaged in setting.

The relation of the worker to the fatigue problem.—The worker himself is an important factor in this question. If he is not the right man for the job, he will undoubtedly suffer much more fatigue in doing the work than will one who is fitted for the task. Take the case of a task requiring a six-foot man; put one a foot shorter in his place, and if the latter can do the work at all it will only be at a wholly uneconomical expenditure of energy. The reverse is equally true, for a tall man at a short man's job will be obliged to stoop continually and be constantly fatigued thereby. The same results are found in the case of mental effort: the man who is put at a task requiring the maximum of his intelligence will be much more fatigued at the end of a certain period than will a man adequately equipped for the task. The man whose mental faculties are not stimulated at all by his work finds, in turn, that he is fatigued by his boredom.

The measurement of fatigue.—Before it is possible to deal intelligently with the problem of fatigue, it is essential to be able to measure it. Various methods have been developed for use in the laboratory, such as Vernon's complex reaction time test, Kent's acuteness of hearing and sight tests, Voit and Petten-Roper's carbon dioxide tests, Ryan's vascular skin reaction test, Mosso's ergograph, von Heinholtz's myograph, Martin and Rich's spring balance test, and many others in addition. However satisfactory these tests may be for use in the laboratory for the purpose of studying the nature of fatigue, they are not adaptable to the needs of the factory. In fact, one of the chief problems, in so far as the practical side of the fatigue question is concerned, is the question of its measurement under normal factory conditons. In general, there are usually only two means of measurement which are used, (1) decrease in rate of production, and (2) decrease in quality of output. It is evident that there are many other factors which affect the rate of production and its quality in addition to the fatigue of the work, and, as it is extremely difficult to keep these factors constant, even over a brief period of time, it is obvious that the measurement of fatigue in the factory can be done only with a rough approximation to real accuracy. Several individuals are making thorough studies of the nature of fatigue and its measurement under factory conditions, and it is to be hoped that, before long, better methods will be available for dealing with this difficult problem.

The reduction of fatigue in the factory.—Before making any allowance or provision for recuperation from fatigue on the part of the workers, there is another step which should be taken in all cases—the elimination of all unnecessary causes for fatigue. It has already been pointed out that the surrounding conditions have a material effect on fatigue which the worker experiences. There is no reason why such conditions should not be made as conducive to the easy performance of the assigned tasks as possible. There is no excuse, in most cases, for an unsatisfactory supply of light. So many different devices have been developed in recent years to modify the supply of natural or artificial light to the needs of almost any operation or place, that there are few processes which cannot be adequately lighted and at a reasonable cost. The effect on the quantity and quality of product is so immediate and beneficial that it is strange that it is so difficult to persuade factory executives to give proper attention to this matter.

Not many years ago for an employee to sit down at his work was considered a sign of laziness. Now it is beginning to be appreciated that it is to the advantage of the management, as well as to that of the man, to provide chairs whenever the nature of the work will allow the worker to sit, even a portion of the time. If not given seats of one kind or another, workers will improvise them, unless strictly forbidden to do so, and in many cases the results are far from being as restful and fatigue-alleviating as they might be. Every one knows from personal experience that all chairs are not equally comfortable, and the comfort depends to a considerable extent on the occupation to be pursued while the workman is seated. A morris chair is quite satisfactory when one wishes to read a book or magazine, but it is hardly appropriate at the dinner table. The same rule applies, also, in the factory; not *all* chairs are designed to go with *all* operations. In fact, a good many so-called factory chairs were never designed for any other purpose except to furnish a profit to the producer, regardless of the comfort of the user. Chairs should be adapted to the needs of the worker at any particular operation. A good illustration of this is shown in Figure 56. It is a chair designed by Mr. F. B. Gilbreth for a man who is doing bench work, principally filing at a vise. The rests at the sides are for his feet so that he can obtain adequate leverage when filing. The height is so adjusted that the man can stand from time to time, and, by a change of position, secure a little rest.



By Courtesy of Mrs. F. B. Gilbreth.

Fig. 56.—Chair Designed to Relieve Fatigue at Bench Work.

The control of the worker over fatigue reduction.—These are simply two examples of the type of conditions which affect the fatigue of the worker, and over which the management has considerable control. If it chooses to take the necessary steps to reduce fatigue by establishing the proper conditions, it can do so. Over these same conditions, also, the worker, as an individual, has little influence; it is only by concerted action and the bringing of pressure to bear on the management in this way, that the workers can affect their surroundings. There are other factors which affect their fatigue, however, over which they do have control and over which the management can only indirectly exert an influence. An illustration of this kind of thing is found in the case of the workers' shoes, especially their heels. There are few things which tire a person more than standing, or even sitting, with heels that are run over at the sides, that are too high. Both of these conditions are found among factory workers, the latter especially in the case of women. The management should do what it can by instruction through bulletins, and in other ways, to call the attention of the workers to this fact and to urge upon them proper attention to their shoes.

While the shoes are the most conspicuous example of this kind of thing, other articles of clothing also fall in the same class. This is especially true of women, and is one of the reasons why uniform clothing to be worn during working hours has been provided by many concerns for their women employees. The habits of life of the workers outside of the plant also have considerable influence over their fatigue at the time of their tasks. This was particularly noteworthy of drinking before the time of prohibition in this country, and is still true of late dancing parties, joy-rides, etc., which rob the workers of their needed sleep. Over such matters the management has no control and little influence.

Fatigue allowances and rest periods.—When all possible causes of fatigue have been eliminated, there is still the problem of providing for the fatigue which cannot be eliminated. It was suggested in the preceding chapter that a percentage of the net standard time be added thereto to provide for the fatigue which is sure to come from the performance of the task. This is one of the two ways which are commonly used in actual practice; the other method is to establish rest periods during which the machinery is stopped, the workers are allowed to walk about, talk, eat, smoke—if ordinances do not forbid it—and amuse themselves in any reasonable way. In the case of office workers and shop employees whose work involves little movement, a few moments of calisthenics may be given.

The matter of rest and recuperation from fatigue can be better controlled by this latter method, but it is less used than the former because of certain practical disadvantages under many conditions. Wherever the work of all the employees in a certain department is substantially the same in so far as the amount of fatigue is concerned, it is then possible to provide rest periods so that all the employees will be either working or resting at the same time. Under such conditions this method works out satisfactorily, but if the various tasks demand rest periods at different intervals, then the results are seldom what are desired. If some of the workmen are resting, they are almost certain to disturb the others with their conversation and movement, even when they leave those who are still engaged at their tasks strictly alone. It is very difficult to accomplish this, however, for, when a man has nothing to do and has friends near by, it is but natural for him to want to talk with them. As a result, most of the time becomes a rest period for the majority of the employees in the department, and the effect on production is disastrous.

Under such conditions it is much better to have recourse to the other method suggested, namely, to add a percentage to the net standard time as an allowance to provide for fatigue.

The problem arises as to the way in which the percentages may be determined for a large variety of operations. If it were necessary to do so for each individual operation it would be an impractical task. Fortunately, in most cases, it is possible to group the various jobs or operations into groups which are substantially alike in so far as fatigue is concerned. In making this grouping the judgment of the time study engineer and personnel manager must be relied on to a considerable extent. A careful study of the kind of work done at each machine is helpful in deciding upon the fatigue class into which the jobs done upon it should be placed.

Setting fatigue allowances and rest periods.—Once the jobs have been classified from the standpoint of fatigue, it next becomes necessary to decide on the length and frequency of the rest periods or the per cent of the time allowance for fatigue. In both of these cases, the only way to proceed is by experiments. This is especially true in the case of the rest periods, for, if they are not set properly, losses are likely to result, because not enough rest is provided, because it is arranged at inappropriate times, or because too long periods are planned—more time than necessary to allow the workers to recuperate from their fatigue. In either case production suffers. Much the same thing can be said in the case of the time allowance. Past experience with similar kinds of work is often helpful in making proper provision for fatigue.

Conclusion.—Fatigue is one of the most difficult of the problems involved in the setting of manufacturing standards. The method for performing an operation must always give it due consideration, for no method is a good one which involves more than the minimum of fatigue. Fatigue always results wherever human beings are working and hence it is present to a greater or less extent in all factory operations. When it has been reduced so far as possible, it is necessary to take account of what cannot be avoided in the setting of the operation standards. It is the least controllable, the least easily measured of all the factors which affect the setting of manufacturing standards, and is a field to which increasing attention should be given.

References for Additional Reading.

Gilbreth, F. B., and L. M., "Fatigue Study," Chapters I-III, V-IX.

Goldmarck, J., "Fatigue and Efficiency," Chapters II, III-V.

Jones, E. D., "The Administration of Industrial Enterprises," Chapter XI.

Lichtner, W. O., "Time Study and Job Analysis," Chapter XIV.

CHAPTER XVII

MAKING STANDARDS PERMANENT

Purposes of this chapter.—

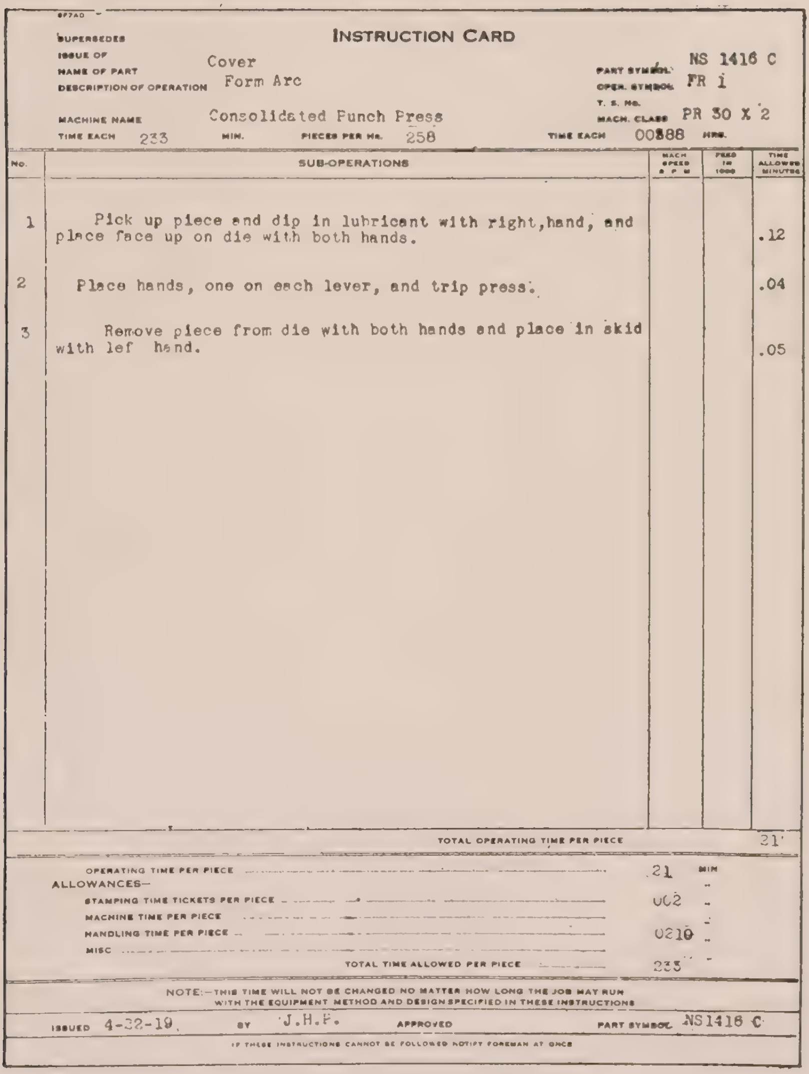
1. To survey the problem of making standards permanent.
2. To outline the procedure for preparing instruction cards and standard practice instructions.
3. To investigate methods for the instruction of employees.
4. To consider the relation of incentives to the permanency of standards.

It is obviously useless to go to all the expense of setting manufacturing standards of various kinds unless they can be given at least a relative degree of permanency. For some of the standards a record is made which serves as the basis of permanency, as in the case of the specifications of materials and more recently in the case of operation standards and standard methods of doing routine work in the form of instruction cards and standard practice instructions. Such records are essential steps in the direction of the real permanency of the standards which have been established, but they are not the whole story. Many concerns are nicely equipped with records of this kind, and the higher executives assume that because of this the work is being done according to the standards which have been set. All too frequently this is not the case, however; but old, discarded methods and quality standards long since thought to have been discarded are still in use. The reasons for this state of affairs are two: (1) lack of proper instruction in the meaning and significance of the standards and in the standard way of doing the work, and (2) lack of incentive to the worker to do work in the way prescribed and up to the quality desired. To render standards really permanent after they have been set, three things are, therefore, necessary: (1) a permanent record of the standard, (2) definite instructions to the workers in regard to its use, and (3) a positive incentive to encourage them in its maintenance.

Operation and routine work standards.—The ways in which records for some of the standards can be prepared have already been discussed to some extent in preceding chapters—equipment, materials, workers—and lack of space forbids further consideration of them here. Ways for recording operation standards and standard methods for routine work have not been explained, and, from the point of view of control of factory operations, they are probably the most important of all. In general, there are two different ways of recording the methods for doing work, methods which differ in detail, but not in fundamental principle. Both of them involve the careful, written explanation of how a job should be performed. If the task is one which occurs irregularly, and usually at infrequent intervals, the record which is made of the operation standard is ordinarily called an "instruction card"; if the operation is of a routine nature occurring regularly and frequently, the record is commonly called a "standard practice instruction." Instruction cards are seldom found outside the shop, and in the shop only in the case of the jobbing and intermittent type of industry.

The instruction card.—The instruction card and the standard practice instruction, in so far as the shop is concerned, is the direct result of the final time and motion studies which have been made of the job. An illustration of an excellent instruction card is shown in Figure 57. It will be noted that all the essential information needed for the performance of the job in question, in so far as the operator is concerned, is recorded on the card. There are names of the part, the part symbol, the operation symbol, the machine class symbol, the machine, the tools required, and instructions about the time ticket for the job. As there is a set-up man to see that the die is properly put into the punch press, no instructions to this end are given to the workman, and as this part of the operation depends largely on the individual skill and judgment of the set-up man, only general directions to him are included. To aid in visualizing the product which is being made, a sketch thereof is shown with certain of the more important dimensions from the standpoint of this particular operation.

On the reverse side of the card are listed the several sub-operations which serve to make up the complete operation and the net time allowed for each. A description of how the complete operation is to be done is given in detail according to the sub-operations. Theoretically, a workman should be able to perform the task with no further instruction than is given here. Practically, he needs to be taught as well as to be provided



6774D

INSTRUCTION CARD

SUPERSEDES
ISSUE OF
NAME OF PART Cover
DESCRIPTION OF OPERATION Form Arc
MACHINE NAME Consolidated Punch Press
TIME EACH 233 MIN. PIECES PER HR. 258
PART SYMBOL NS 1416 C
OPER. SYMBOL FR 1
T. S. NO.
MACH. CLASS PR 30 X 2
TIME EACH 00888 HRS.

No.	SUB-OPERATIONS	MACH SPEED R. P. M.	FEED IN 1000	TIME ALLOWED MINUTES
1	Pick up piece and dip in lubricant with right hand, and place face up on die with both hands.			.12
2	Place hands, one on each lever, and trip press.			.04
3	Remove piece from die with both hands and place in skid with lef hand.			.05
	TOTAL OPERATING TIME PER PIECE			21'

OPERATING TIME PER PIECE .21 MIN
ALLOWANCES—
STAMPING TIME TICKETS PER PIECE 002
MACHINE TIME PER PIECE
HANDLING TIME PER PIECE 0210
MISC
TOTAL TIME ALLOWED PER PIECE 233

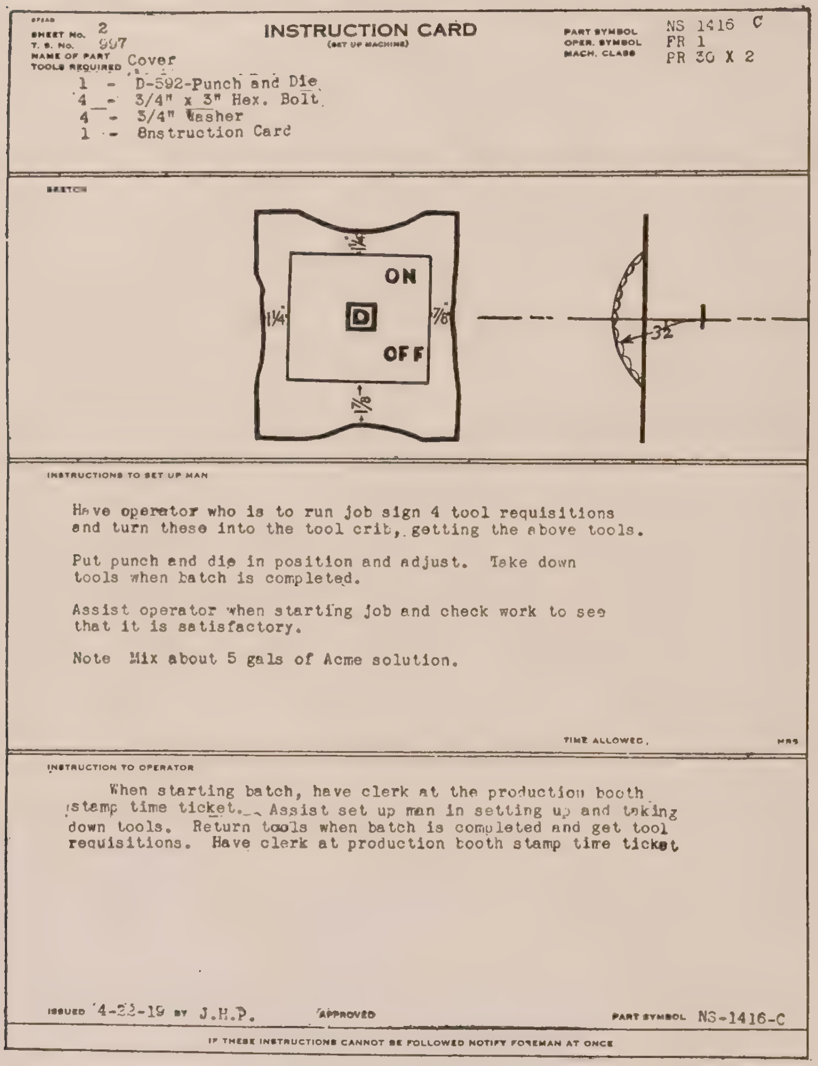
NOTE:—THIS TIME WILL NOT BE CHANGED NO MATTER HOW LONG THE JOB MAY RUN WITH THE EQUIPMENT METHOD AND DESIGN SPECIFIED IN THESE INSTRUCTIONS

ISSUED 4-22-19 BY J.H.P. APPROVED PART SYMBOL NS1416 C

IF THESE INSTRUCTIONS CANNOT BE FOLLOWED NOTIFY FOREMAN AT ONCE

Fig. 57A.—Instruction Card.

with a textbook. The unit times which are shown are those which result from the calculations explained in Chapter XV. The allowance for fatigue and personal necessities is lumped together in this illustration. It is better practice, in most cases, to keep the allowances for different exigencies separate. It will also be noted that columns are provided on this card for



SHEET No. 2
T. S. No. 997
NAME OF PART Cover
TOOLS REQUIRED

INSTRUCTION CARD
(SET UP MACHINE)

PART SYMBOL NS 1416 C
OPER. SYMBOL PR 1
MACH. CLASS PR 30 X 2

1 - D-592-Punch and Die
4 - 3/4" x 3" Hex. Bolt
4 - 3/4" Washer
1 - 8nstruction Card

SKETCH

1¼"
ON
D
1¼"
7/8"
OFF
1 7/8
3½

INSTRUCTIONS TO SET UP MAN

Have operator who is to run job sign 4 tool requisitions and turn these into the tool crit, getting the above tools.

Put punch and die in position and adjust. Take down tools when batch is completed.

Assist operator when starting job and check work to see that it is satisfactory.

Note Mix about 5 gals of Acme solution.

TIME ALLOWED, HRS

INSTRUCTION TO OPERATOR

When starting batch, have clerk at the production booth stamp time ticket. Assist set up man in setting up and taking down tools. Return tools when batch is completed and get tool requisitions. Have clerk at production booth stamp time ticket

ISSUED 4-22-19 BY J.H.P. APPROVED PART SYMBOL NS-1416-C

IF THESE INSTRUCTIONS CANNOT BE FOLLOWED NOTIFY FOREMAN AT ONCE

Fig. 57B.—Instruction Card.

data concerning the machine—speed and feed—which, though not needed in this instance, are essential for many kinds of machinery.

The preparation of instruction cards and standard practice instructions.—It is essential in preparing an instruction card or standard practice instructions to be definite and explicit, to leave nothing to the imagination. To just what extent details shall be recorded depends on the circumstances. If the job is not to take long and there is little likelihood of its ever being repeated, as is frequently true for the job shop, brief instructions are all that there will be time to prepare. The time standards are almost certainly only approximate in such cases, and the workmen are more highly skilled and possessed of greater initiative than those who are commonly employed in a continuous process type of factory. Hence, more can be left to their judgment and discretion than would be possible with lower grade employees.

For continuous process work, which is routine in its nature, less intelligence is required for its acomplishment, especially if the conditions under which it is performed are carefully controlled. It is astonishing how complicated a job an unskilled, untrained worker can do if the work is standardized, surroundings are controlled, and he is carefully and thoroughly instructed in the duties of his position. As a basis for this instruction detailed instruction cards or standard practice instructions are required.

In all instances homely, easily understood English is necessary. Simple, declarative sentences should be employed. Any tool, part, action, etc., should always be described by the same word whenever it is referred to, and no effort should be made to employ synonyms which, however much they may add to the literary excellence of the composition, seriously detract from its practical usefulness. Pronouns, of course, may be used, but they should be employed where there is the slightest chance for ambiguity. In case of doubt, repeat the noun. Clarity is the first essential in all cases. In preparing standard practice instructions, a sequence of sub-operations should always be numbered and the arrangement of the various steps to be taken carefully indicated. Standard practice instructions and instruction cards should be thought of as textbooks for the benefit of the workers, and textbooks, whether in the school or the shop, are essentially tools, a means to an end. In some factories, instruction cards are mounted on sheet metal, coated with shellac, and stored in the tool crib when not in use, to be issued as are the other tools which are required for the job.

Classes of standard practice instructions.—There are frequently two classes of standard practice instructions: (1) those which contain instructions for doing the work of any particular position when the tasks are of a routine nature such as moveman, storekeeper, foreman, balance of stores, clerk, etc., and (2) those which contain instructions for handling a certain form as it passes from position to position, as, for example, a group issue, receiving slip, time ticket, etc. There is usually need for the second kind of standard practice instructions, for forms which remain at one place like the balance of stores cards, the stores journal, the general ledger, etc., as sufficient information is given about them in the explanation of the work of the several positions. There is likely to be a certain amount of overlapping between the two sets of standard practice instructions, but this does no harm, unless there is an excessive amount of it; it serves rather to give a cohesiveness which, in general, is desirable.

Standard practice instructions should be drawn up for all routine work, no matter who may be responsible for its accomplishment, or how high his position may be. There is almost always a certain amount of routine work to be performed no matter how much of the task of any position may seem to be that of forming policies or taking care of exceptions. Of course, in such instances, the standard practice instructions will be briefer, more general, and confined to the routine features of the task, but they should be prepared nevertheless. Hence, the production manager, the production engineer, the superintendent, the factory manager, and all the other factory executives, as well as those in charge of the other functions of the business, should have standard practice instructions prepared for their benefit; in some cases they should prepare them themselves. In so far as the factory is concerned, however, the production engineer, and his associates and assistants, prepare most of the standard practice instructions, as the routine methods of production control are just as much a part of the manufacturing standards as are the standards of operation for the directly productive processes.

Such standard practice instructions should be prepared on the basis of a thorough study of the methods to be employed, a study which is comparable in the manner in which it is to be undertaken to the making of a time and motion study of an operation in the shop. It should be remembered in this connection that, because the work is so often repeated, it is especially essential that the procedure to be followed should be the best possible in order to eliminate the accumulation of small losses.

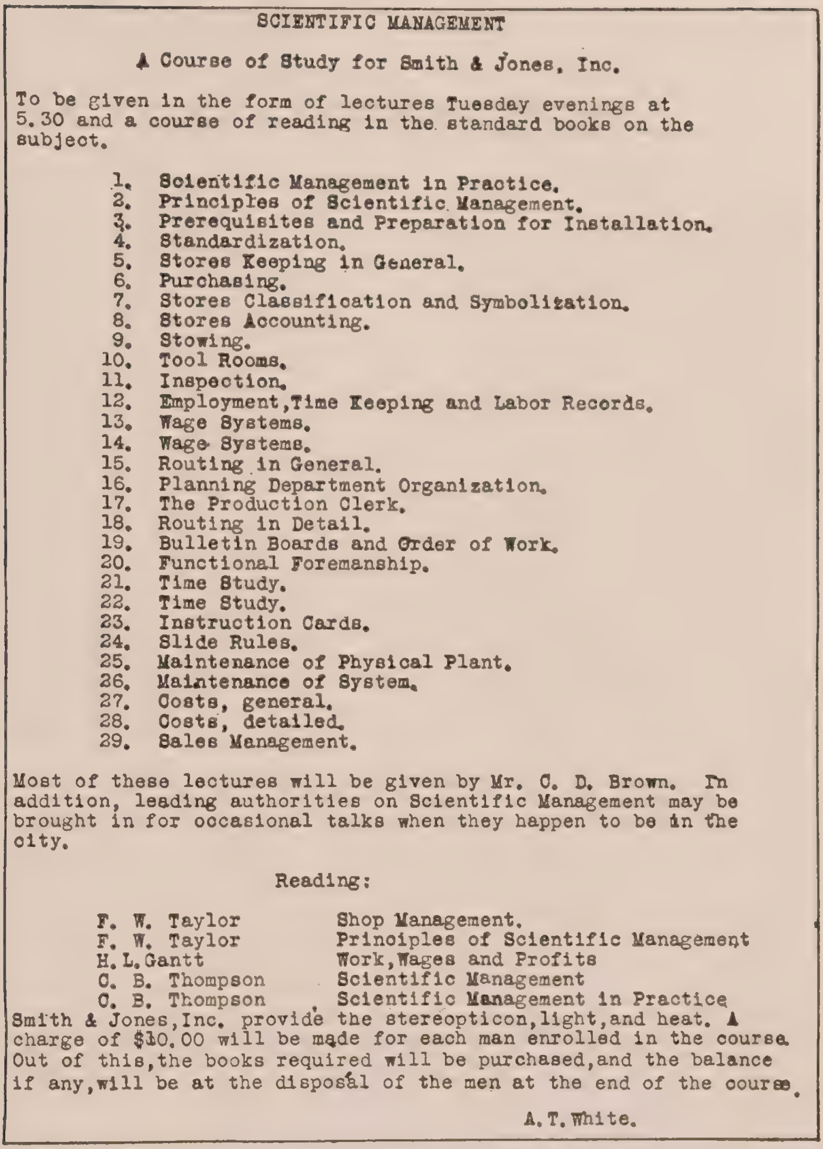
Continuous instruction of the employees.—When the operation standards and standard methods of doing routine work have been reduced to writing, there still remains the problem of teaching them to the workers. There are a number of ways of accomplishing this, the most direct of which is personal instruction on the job. Some concerns have found it desirable to assign each new worker in the shop to an instructor who is made responsible for his training in the details of the task to which he has been assigned and maintains constant supervision over him so long as he remains on that type of work. This is rather an extreme case, this constant teaching of the job; but in the jobbing and even, in some cases, in the intermittent type of factory, it is well worth while to go to this expense in order to make sure that the work is being done as it should be. The increased control of production and the reduced spoilage and waste of materials more than pays for the cost of the instruction. In this type of work, also, the need for constant teaching is much greater than it is in the case of the process type of industry because of the ever changing nature of the details of the various jobs.

Instruction by foremen and subforemen.—In many concerns, the necessary instruction can be given by the foremen and subforemen, especially when they are relieved of the task of planning and scheduling the work in their department, with the attendant worries, which use of instruction cards and standard practice instructions implies. In fact, teaching of the workers is one of their principal tasks under such circumstances, though it is frequently masked under the term "supervision," which often is not a bad thing when foremen and workers are inclined to balk at anything which savors of a school. The same kind of task exists for other department heads who have control of functions outside of the shop—the production manager, the purchasing agent, the cost accountant, even the production engineer himself. The duty of teaching their subordinates is ever present.

General training of employees.—In many instances instruction in specific tasks has been ineffective because of an inadequate background. For this reason it is often necessary to extend the training which is given an employee back of the immediate job on which he is engaged and give him instruction on matters which do not have an immediate bearing on the problem at hand. This is one of the causes for the training schools which certain companies have developed in recent years. A notable example is that of a concern which provides an opportunity for the workman in its shop to go to this school and receive instructions on the various kinds of machines with which it, in common with most metal working shops, is equipped. They receive a certain per cent of their previous rate of pay while in this school, and an increase when they go back to the shop after completing their instruction successfully on a particular machine. After a few months they are permitted to return to the school and be taught the operation of another kind of machine. In a few years they are familiar with the company's shop methods and, in addition, are well-trained all-around mechanics.

A course of lectures.—Other companies have found it advisable to give even broader training as part of their effort to give their men such a background that the operations which they are performing will have a proper setting. If a man does a thing simply because he is told to do so, he often begins to do it a little differently, not from any desire to depart from the standards which have been set, but simply because he has no basis for checking what he is doing due to a lack of knowledge of what the whole matter is about. This point is especially important at a time when standards and new methods of control are being developed. One concern arranged for a series of lectures which all department heads and their chief assistants were expected to attend and to which others were invited to come if they so desired. The bulletin (see Fig. 58) announcing this series indicates its scope.

Regular courses at night school or factory.—In other cases it has been found desirable to give courses in accounting and cost accounting to factory employees, especially to the foremen



SCIENTIFIC MANAGEMENT

A Course of Study for Smith & Jones, Inc.

To be given in the form of lectures Tuesday evenings at 5.30 and a course of reading in the standard books on the subject.

1. Scientific Management in Practice.
2. Principles of Scientific Management.
3. Prerequisites and Preparation for Installation.
4. Standardization.
5. Stores Keeping in General.
6. Purchasing.
7. Stores Classification and Symbolization.
8. Stores Accounting.
9. Stowing.
10. Tool Rooms.
11. Inspection.
12. Employment,Time Keeping and Labor Records.
13. Wage Systems.
14. Wage Systems.
15. Routing in General.
16. Planning Department Organization.
17. The Production Clerk.
18. Routing in Detail.
19. Bulletin Boards and Order of Work.
20. Functional Foremanship.
21. Time Study.
22. Time Study.
23. Instruction Cards.
24. Slide Rules.
25. Maintenance of Physical Plant.
26. Maintenance of System.
27. Costs, general.
28. Costs, detailed.
29. Sales Management.

Most of these lectures will be given by Mr. C. D. Brown. In addition, leading authorities on Scientific Management may be brought in for occasional talks when they happen to be in the city.

Reading:

F. W. Taylor	Shop Management.
F. W. Taylor	Principles of Scientific Management
H. L. Gantt	Work,Wages and Profits
C. B. Thompson	Scientific Management
C. B. Thompson	Scientific Management in Practice

Smith & Jones,Inc. provide the stereopticon,light,and heat. A charge of $10.00 will be made for each man enrolled in the course. Out of this,the books required will be purchased,and the balance if any,will be at the disposal of the men at the end of the course.

A.T.White.

Fig. 58.—A Course of Lectures for Plant Employees.

and subforemen, in order to show how their work affects that of others, and to indicate how necessary it is for them to maintain accurately the records which pass through their hands. One concern urged their men to attend the night school courses which were given in the city in these subjects, and refunded to those who successfully completed their courses one-half of what they paid for tuition. This plan proved to be so successful that the following year they had classes in the same subjects given at the factory for the greater convenience of their students. The effect was soon noticeable in the improved work of their employees; they not only worked more accurately but also with more enthusiasm, because they better appreciated the significance of the part which their task was of the whole job.

Talks by department executives.—Another case which bears more directly on the making permanent of the standards once established is that of a concern which required each of its department heads to prepare a lecture on the work of his own department. The lectures were then mimeographed and given to the other department heads who had heard the talk given by their colleagues. The following paragraphs are taken from one of these lectures:

REPORT ON THE FUNCTIONS AND DUTIES OF THE PLANNING DEPARTMENT OF THE SQUARE D COMPANY, DETROIT, MICHIGAN

- Function of the Planning Department
  - Recording
    - Material Record Cards
    - Shipping Orders
    - Authorization Cards
    - Purchase Requisitions
    - Issues
    - Time Tickets
    - Bonus Tickets
    - Receiving Slips
    - In-slips
    - Work Orders
    - Obsolete Parts
    - Salvage Reports
  - Scheduling
    - Shortage Reports
    - Back Issues
    - Operation Check Cards
    - Production Booth Routine

"**Function of the planning department.**—The function of the Planning Department is to control and direct all productive material and labor.

"Under the Taylor system of scientific management, planning resolves itself into performing certain well defined operations in the proper sequence—such as ordering raw stock, seeing that it is worked up into the proper parts, seeing that the final product is assembled as soon as returned.

"In order intelligently to plan the control of labor and material, certain information must be furnished the Planning Department. The Management determines what is to be made; the Sales Department by their sales determines when and how many are to be made; and the Engineering Department furnishes a parts list showing all the material required, and a part card showing the method of manufacture of each part.

"Material record cards are made out on all items of merchandise, worked and purchased material. These are made out from part cards, furnished by the Production Engineering Department, which give all the necessary information such as monthly quantity, order quantity, material, etc.

"A minimum is carried on each card which includes the amount to be carried in stores plus enough to cover the time to manufacture or purchase, as the case may be. In the latter case, the time to buy which changes with market conditions, is furnished by the Purchasing Department.

"The material record cards are divided into the following five columns: Requirements, Ordered, Apportioned, Received, and Issued.

"The Requirements column has the total minimum posted in it, together with the shipping orders in the case of merchandise, and the authorizations in the case of stores parts. This column, as its name implies, shows the amount required to fill all shipping orders and still maintain the proper minimum.

"Purchase and production orders are posted in the Ordered column. When the Order falls behind the Requirements, a purchase requisition is written for a standard quantity on a purchased part and a yellow tag is placed on the card if it is a manufactured product.

"The Apportioned column has the shipping orders or authorizations posted in it as in the Requirements, together with only that minimum that is to be carried to the storeroom.

"The Received column has receiving slips or in-slips posted in it, depending on whether the part is purchased or manufactured. When the Received falls behind the Apportioned, a green tag is placed on the card, regardless of whether it is purchased or manufactured.

"All issues are posted in the Issued column.

"Shipping orders are posted on the merchandise cards and checked off as soon as filled. They are to the Planning Department what steam is to an engine, for the rate of production is determined directly by the amount of orders.

"The total switches sold are posted once a week on authorization cards which may be likened to a governor on an engine. They regulate the rate at which orders must be sent through the plant. Batches are sent through the shop in standard quantities. As needed, an authorization is written authorizing the building of a certain quantity. When business is on the increase, these quantities may be increased to good advantage and vice versa. The authorizations are extended across the material record cards for stores by means of parts lists. By this means, rather than by posting shipping orders direct to all cards, the clerical work is reduced to a minimum.

"Special work, required for tool or machine maintenance, or for service orders, as the case may be, is performed on work orders which are handled much the same as a production order.

"A record of all obsolete switches is kept, and a report of the quantity on hand of each is issued once a week. This report is used by the Sales Department in trying to move such stock.

"Other obsolete material is carried in service stores by the Engineering Department after it has been charged off the material record cards to the Change in Design account. Salvage tickets are made out on all scrapped material, showing the part and amount, the accounts charged and credited, and the cause and disposition of the material.

"Shortage reports are made out at stated times during the week showing the condition of all the material record cards that are behind schedule.

"The primary delay report, which is a report on the cards bearing yellow tags, is used by the schedule clerk in releasing orders to the shop, for these are the cards on which the Ordered is less than the Requirements.

"The final delay report, made from cards bearing green tags, is used mainly by the production booth clerk. Items appearing on this list are given preference over items that do not appear, for they are the ones that have not been received in sufficient quantity to meet production demands without eating into the minimum that should be carried in the storeroom.

"A shortage report is made out showing all parts that are holding up production or shipping orders, and is used mainly by the production booth clerks in speeding up such parts through the plant. Parts appearing on the shortage report are given preference over all others.

"An operation check card is made out by the schedule clerk on all production orders. On it is posted the amount of the order and a list of the operations required. Bonus tickets and in-slips are also posted, giving a complete history of every order as it travels through the plant. The schedule clerk also writes up in advance, by use of the part or assembly card, a complete set of time tickets, issues, and in-slips.

"A back issue is made out in the storeroom when there is not enough material on hand to fill an order. This is sent to the schedule clerk and is posted on the back of the operation check card for reference. It is then clipped with a red tag to the corresponding material record card. It is then evident that cards bearing red tags are the ones that are used in making out the shortage reports.

"When an operation is to be performed on any material, a set-up notification ticket is delivered to the tool crib, and one to the set-up foreman as advance notice to get dies, tools, etc., ready before the set-up is given out. The operator is given a set-up ticket while his job is being set up. When complete, he turns this in with a set-up notification ticket signed by the floor inspector and receives a time and bonus ticket. When the job is completed, the material enters the count on the bonus ticket and the operator turns it in and receives another assignment.

"It is quite essential that accuracy be observed throughout the plant when records are being made out, for these are used by the Planning Department in the control of labor and material, and unreliable information is quite useless and often quite costly."

G. H. Jacobson.

The benefits from this procedure are realized in two ways —the man who prepares the lecture must familiarize himself thoroughly with the work of his department and the way in which it is actually being done; as a result, he is likely to find many cases where the standards are not being maintained and should be enforced and sometimes he finds an opportunity, hitherto overlooked, to improve the standards. In addition, all the department heads and their chief assistants have a chance to find out about the work of other departments and so gain a better perspective of their own tasks.

Factory hands are informed of management policies.—This same company decided that information of this kind would be of benefit to all their employees, and conceived a novel and effective way of getting the more essential points to them. A well-written summary, prepared in a newsy style, of each of the lectures was printed in the house organ. In this way a readable outline of the work of the various departments was placed in the hands of every employee. A copy of the first of these articles follows.

Square D Tales.

Published by the Square D Company.

"**A. Principles of Scientific Management.**[1]—Perhaps the best illustration of the subject of Scientific Management, what it is, what progress it has made, etc., can be secured by going back in business history some twenty-five years and making comparisons between the principles and details of management in use in those days and the principles and details of management in use in our present day, particularly applying to the manufacturing division.

"Science and skill have been forced into the organizations the past years, because competition is keener, living costs have risen, and labor conditions have changed, and because of uncertain material markets, different methods of selling, etc. We have daily been extending our efforts, keeping pace with the man next to us, until finally we have surrounded ourselves in our own plant with the principle necessary in present-day business—scientific management.

"Our new building is now being completed. This will give us much more space and enable us to secure better and more production. It allows us to arrange our machinery more progressively and gives us opportunity to secure more definite control of equipment necessary in production. We will have more storage space for semi-finished and finished products, which will allow us to keep our productive departments free and clear of unnecessary materials; this again, giving us increased production.

---

[1] Adapted by permission from the November, 1920, number.

"An idea comes to our mind of a new product. It is turned over to our development man to put into a working model. In doing this, many things are perhaps taken into consideration. Is the new product a practical one? Is it salable? If so, how large is our field for selling? Is it of national or international scope?

"When this product is designed, attention must be given to its shape, its neatness of construction, colors to be painted or enameled, etc. The cheapest, yet the best materials are to be used in its construction. Oftentimes our design and construction would make or break the article from a sales standpoint. At the same time, packing and shipping must also be taken into consideration. These are only a few of the items which are considered in the development of a new product, and all of these items and thoughts, applied, are efficiency, or scientific management.

"Our departments have all been standardized. We know just what is to be done, how it is done, etc., through standard practice instructions, etc. And so our product may be routed through the organization in the most efficient method.

"Certain drawings are necessary for producing the device. Tools, dies, jigs and fixtures, etc., are designed and constructed to meet the requirements necessary in production. These items are recorded on our production engineering records which in turn are used in planning production through the shop. Time studies are made of the various operations necessary to produce the article, whereby we set standard times and fix a bonus rate for those doing better than the standard time. This method insures the better operator being paid in accordance with the work produced, and at the same time increases the efficiency of each individual group of employees, or departments as a whole.

"In purchasing materials for our products, where can we buy at the least cost? Where can we secure the best deliveries? Who has the best grade of goods for the money? Who will ship us in whatever quantities we might have on our schedule?

"These are all questions answered by our Purchasing Department, through their records and systems, devised and designed to handle efficiently the duties of this department.

"In our machine shop, we have the latest type machinery, equipped with modern safety devices to prevent accidents to our employees. The parts are all scheduled through this as well as the other manufacturing departments by the Planning Department, one operation following the other in respective order.

"Our Box Assembly Department is equipped with electric spot welders, enameling ovens, and other labor saving devices necessary in production at a minimum cost.

"The Switch Assembly Department operates on what is termed progressive assembly. That is to say, operations are separated and assemblers are responsible for only their operations in the final assembly.

"Besides the major manufacturing operations, there are a number of so-called non-productive operations, such as inspection, storing, receiving, shipping, etc. To cover all of these functions completely would fill a book. The purpose of this article is to call attention to the 1920-1921 lecture course on the principles of scientific management as applied in our plant. Lectures on the functions and routine of the several departments will be given on the first and third Thursdays of each month, commencing in December. Anyone interested is invited to attend."

As far afield as some of the methods mentioned may seem from the primary object—making the standards permanent in actual practice—much of this more generalized instruction is most effective in attaining the desired goal. It is a question of arousing the employee's interest and awakening in him the will to do as he is requested to, quite as much as it is a matter of conveying to him a certain amount of intellectual information.

The relation of incentives to permanency of standards.—This naturally leads to a consideration of the relation of incentives to the permanency of the established standards. If the standards are to be maintained, some incentive must be given the workers or there will be a tendency on the part of most employees to neglect them. There are many different kinds of incentives which have their effect on this matter—fear of losing the position, desire for promotion, pride in work well done, competition with other workers or between shops, increased wages, etc. All of these have varying degrees of importance, but it is only to the one last mentioned that attention will be given here. The social and economic phases of the wage question, important as they are to the management as well as to the worker and society as a whole, are beyond the scope of the present discussion.

For any wage or method of wage payment to be an incentive to doing work as has been prescribed and within the time set for the job, several essentials are necessary.

1. The incentive must be a real addition to the base wage that is current for the type of work in the community. A base wage to which the bonus or premium must be added to bring it up to the average level of wages is not an incentive.
2. The bonus or premium should be the direct result of the workmen's efforts and compliance with the requirements expressed in the standard. The worker should be able to see clearly the relation between cause and effect.
3. The bonus should be paid frequently, as often as the regular wages are, though not necessarily at the same time. Most men are not able to evaluate a distant future event. "A bird in the hand," etc., applies with full force to them.
4. The incentive should be easy of comprehension, that the employees can readily understand how they are gaining from their exertions and obedience. What a man does not understand, he is likely to distrust.
5. The method adopted should be simple in operation, to reduce the amount of computation required to a minimum. This is especially important from the standpoint of cost accounting.
6. It is usually wise to make time rather than the dollar the basic unit on which payment is calculated. Adjustments to meet a rising or falling base wage scale can be made more easily if this is done.
7. The incentives must be based on fairly and accurately determined standards. If the standards have developed in the ways which have been described, this condition will be met.
8. The incentive method of payment must be flexible to meet the needs of various kinds of tasks. A greater incentive is necessary if the work involves severe physical or mental labor, or both together, than if the job is light and easy.

9. There should be no cutting of the rate of incentive once it has been set unless the methods of doing the work are radically changed. Changes in wage levels may affect the base wage, but they should have no influence over the *rate* of incentive payment.

10. A minimum should be guaranteed to protect the workman against accidents or faults in management over which he has no control.

An incentive method of wage payment worked out with due attention to these points will have, in most cases, a helpful influence over the maintenance of the standards which have been established.

Conclusion.—From the foregoing discussion it should be evident that instruction of the workers in the use of the standards which have been established is essential to their permanency; that operation standards and standard methods of procedure should be reduced to writing as a basis for this instruction; that, in many instances, a background training must be given to serve as a starting point for specific instruction; and that often incentives of one kind or another must be provided to give the workers a needed stimulus.

References for Additional Reading.

Duncan, J. C., "Principles of Industrial Management," Chapter XV.

"Library of Factory Management," Volume VI.

Lichtner, W. O., "Time and Study and Job Analysis," Chapters XVI, XVII, XIX.

Tead and Metcalf, "Personnel Administration," Chapters XIII, XXIII, XXIV.

Chapter XVIII

CLASSIFICATION AND SYMBOLIZATION

Purposes of this chapter.—

1. To study the meaning of "classification" and "symbolization."
2. To investigate the significance of classification and symbolization in the operation of a factory.
3. To outline a typical symbolized classification for the use of a manufacturing concern.

Classification.—One of the basic tools of all scientific work is the classification of the elements from an analysis. Unless a classification is made, the scientist soon finds that he is burdened with a mass of detail in which essential facts are almost sure to be lost and out of which it is almost impossible to deduce any significant relationships. In order to avoid this difficulty, he classifies this data as he goes along and so produces an approximation of order, at least, out of what otherwise would be chaos. "Classification," therefore, is the orderly and systematic arrangement of data according to similarities and differences which may exist among factors, elements which are alike in a certain respect being set off from others which are unlike in this respect. The division and segregation of data in this way can be carried to any extreme that may seem desirable.

Symbolization.—"Symbolization" is something which is separate and distinct from classification, though the two are so intimately related in many instances—like "cup and saucer" —that they are often thought of as inseparable. In the broad sense of the term, "symbolization" means the giving of a name to any thing or act. The word "lathe" is a symbol for the actual, physical object, and in many cases symbolization goes no further than this. In the more technical meaning of the word, however, it implies a shorthand way of identifying whatever is referred to. Science offers a familiar illustration of this in the case of chemical symbols where "O" is the symbol for the gas, oxygen being derived from the longer symbol for the same substance, its name, "oxygen," and so on for the other elements, such as "N" for nitrogen, "C" for carbon, "S" for sulphur, and longer symbols such as "Fe" for iron, "Ag" for silver, etc. The same idea is carried over from the elements to the compounds and "NaCl" is found as the symbol for common salt, "H_2O" for water, etc.

The relationship of symbols to classification.—It should be evident from this that "classification" and "symbolization" are two different things but that they must go together to be most useful. It is very difficult to classify in a satisfactory fashion unless there are symbols or names available for the items which are being classified. It is quite possible to give things names or symbols without in any way classifying them, but the symbols have far more significance and are much more useful if they are given in connection with the classification and thus indicate important existing relationships and differences.

The significance of classification and symbolization in factory administration.—It should be obvious from the discussion in the preceding chapters that it is necessary for the business manager, and for the factory executive in particular, to give attention to the question of classification and symbolization because of the many details which the operation of even a simple business involves. This subject has already been touched upon in the chapter on the functionalization of a business, and the importance of an adequate symbolized classification of functions was indicated. The natural subdivisions of the activities which are carried on by the various departments are the routine operations and processes which are represented by the standard practice instructions and instruction cards which have already been described. In addition, there are machines, tools, types of workers, and materials of many different kinds. This last item often represents the most varied and numerous group which demands classification and symbolization, for many concerns have inventories, running into thousands of items, in some cases as high as forty or fifty thousand. It is impossible to keep track of and record such a variety of materials unless there is some systematic way provided for grouping and identifying the various units.

A symbolized classification of things and operations in a manufacturing plant is not a basic matter, except in so far as it is fundamental to do what has to be done in an orderly and systematic fashion. It is, however, one of the important aids of which the executive can avail himself, and it is not a sign of good business judgment when he fails to do so. In all attempts to develop the science and art of business management, attention is given to this matter and progress is being made rapidly in this respect. In so far as the factory is concerned, the classification and symbolization of its operations, materials, equipment, etc., are logically a part of the development of the various manufacturing standards, for classification and symbolization serve as a basis for the interrelationship of these standards and facilitates their use after they are established.

Methods of symbolization.—Any classification will depend on the kind of matter to be classified and the needs which the classification must meet. Hence, it is rather difficult if not impossible, to consider it in general terms. In respect to symbols, however, the problem is a little easier to discuss, for in business there are only two methods of symbolization which are used to any extent—the "numerical" and "mnemonic." The numerical, as the name suggests, makes use of numbers for the purpose of identifying the subject matter. It is the direct outgrowth of the Dewey decimal system which has developed for the benefit of libraries. It has been favored because of the facility with which it can be used with adding and tabulating machines, and because of the backing which it has received from accountants whose habits of using figures has had to do with their advocacy of this kind of symbol.

The advantages of mnemonic symbols.—The mnemonic system of symbolization makes use of both numbers and letters. It is so called because of the aid which it gives the memory through its use of the initial letters of the names of the elements for which the symbols stand, so far as possible, and dimensions, size numbers, etc., which are incorporated as a part of the symbol. This method has certain marked advantages over the other, in addition to the assistance which it gives to the memory. It has much greater flexibility and capacity for expansion, as is indicated by the following table:

COMBINATIONS OF ONE, TWO, THREE AND FOUR NUMBERS AND LETTERS

Number of Units in Combination	One	Two	Three	Four
Number of Digits	10	99	999	9,999
Nulber of Letters (all capitals)	22	484	10,648	234,256

This fact is sometimes overlooked by those who think that a letter can represent only one item in a classification. The *position* of the letter in a symbol has just as much significance as the position of a digit has in a number. No one would mistake 123 for 312 and there is no more reason for MDF meaning the same as FDM. As "I," "O," "Q," and "U" are omitted from the alphabet when they are used for mnemonic symbols, because of their similarity to figures or other letters, ordinarily only twenty-two letters are employed.

The mnemonic symbols have another great advantage over numerical symbols in that they aid in reducing errors. A misplaced decimal point or a transposed figure will often result in serious losses, and they are mistakes which it is exceedingly easy for even a careful person to make and extremely difficult in many cases to detect until much damage has been done. Of course it is possible to transpose letters, but once this is done, the symbol generally looks wrong to any one who is familiar with the symbols employed, and so it is much more likely to be noticed and corrected than in the case of the straight numerical symbols.

The late F. W. Taylor was one of the first to call attention to the desirability of the use of mnemonic symbols, and he and his followers have done much to develop the method and apply it in industry. The following illustrations are taken from the experience of the Tabor Manufacturing Company and show how symbols were planned by Mr. Taylor personally and his long-time associate, Mr. H. K. Hathaway.

The letters "A" to "E," inclusive, are used to designate departments, their activities, and the indirect expenses involved in their operation.

The letters "F" to "W," inclusive (except "I," "O," "Q" and "S"), are applied to products, operations, and direct expenses of production. "I," "O," and "Q" are omitted for the reason noted in a previous paragraph, and "S" is used to denote purchased material (stores) in a state previous to any process of manufacture.

The letters "X," "Y," and "Z" are allotted to plant, real estate, buildings, tools, machinery, etc., and the expenditures incurred in their procurement, when these items represent an increase in the value of the fixed assets.

The following table is the basis for the system of symbolization used at the Tabor Manufacturing Company:

A—Auxiliary departments.
B—Business departments.
C—
D—Manufacturing departments.
E—
F—
G—Grinding machines.
H—
J—
K—
L—
M—Molding machines.
N—
P—Pattern fitting and repairs.
R—Milling cutters.
S—Stores.
T—Taylor—New bold saws.
U—
V—
W—
X—Part construction.
Y—Motive power and machinery.
Z—Land and buildings.

Each letter added to the symbol indicates a further subdivision of the classification. It is interesting to note, also, how this classification is symbolized in respect to orders and operations. The symbol for the part or article to be made is the basis for the order symbol which is constructed by adding a number in a consecutive series to the symbol for the part. The operation symbol uses the same part symbol, but the operation sequence number is prefixed to the part symbol, instead of being added as a suffix, as in the case of the order number.

Classification bases.—The development of a fundamentally correct symbolized classification for a manufacturing concern is no easy task, for it involves a thorough knowledge of the details of the business, as well as of the general problems which must be faced. In the first place, it is necessary to select a basis on which the classification is to be prepared and carefully define it. It not infrequently happens that it is necessary to use one basis in one part of the classification and another in another. It may be wise, for example, to classify parts according to the use to which they are to be put in the fabrication of the product, and raw materials according to their nature. It is essential, however, for the classification to have organic unity, or trouble will be encountered in its symbolization and subsequent use. It must also be so designed as to be easily learned, easy to use in filing records and finding them when wanted, in tabulating figures. It should aid in the reduction of errors and be a help and not a hindrance to those who use it, and hence, result in a saving of time and labor. All this means that it must be logical and definite and as simple as the circumstances of the particular case will permit.

The control of the classification.—In most cases the control of the main outlines of the symbolized classification must rest in some position which has general oversight of the entire business, for the classification affects to a greater or less extent every department of the company. In most cases, the general manager is the best person to do this work, in so far as any details which may interest him are concerned, through some member of his immediate staff, like the assistant to the general manager. The development of the details, however, may be left to members of the various principal functions of the business, who are chosen because of actual contact with the problems involved in the preparation of classification, and with the methods of meeting them. As the largest part of the classification in a manufacturing company concerns the factory primarily, the production engineer is the one who should have control of the development of much of the detail.

A practical approach to the classification problem.—In general, it is wise to use an accounting basis for working out the symbolized classification, for the accounts should furnish a means for recording all transactions and the results of those transactions. The following symbolized classification which is offered as suggestive of the general form in which such a problem should be handled is worked out on this basis:

A—
B—
C—
D—
E—
F—
G—
H—
J—
K—
L—

M—
N—Net worth (proprietorship).
P—Property.
R—Revenue.
S—
T—
V—
W—
X—
Y—
Z—

Property, which is the division that is of most interest here, may be divided as follows:

PA—Assets
PB—
PC—
PD—
PE—
PF—
PG—
PH—
PJ—
PK—
PL—Liabilities.
PM—
PN—
PP—
PR—
PS—
PT—
PV—
PW—
PX—
PY—
PZ—

The entire list of available symbols is shown in all cases to indicate the possibilities of expansion. This is one of the important advantages, it will be remembered, of the mnemonic system of symbols. Assets are further subdivided:

PAA—
PAB—
PAC—Current assets.
PAD—Deferred charges.
PAE—
PAF—Fixed assets.
PAG—
PAH—
PAJ—
PAK—
PAL—
PAM—
PAN—
PAP—
PAR—
PAS—
PAT—
PAV—
PAW—
PAX—
PAY—
PAZ—

The current assets may be subdivided as follows:

PACA—Accounts receivable.
PACB—
PACC—Cash.
PACD—
PACE—
PACF—
PACG—
PACH—
PACJ—Interest receivable.
PACK—
PACL—
PACM—Materials.
PACN—Notes receivable.
PACP—
PACR—
PACS—
PACT—
PACV—
PACW—
PACX—
PACY—
PACZ—

The materials in turn should be subclassified in some such fashion as:

PACMA—
PACMB—
PACMC—
PACMD—
PACME—
PACMF—Finished product.
PACMG—
PACMH—
PACMJ—
PACMK—
PACML—
PACMM—
PACMN—
PACMP—Parts.
PACMR—
PACMS—Supplies.
PACMT—
PACMV—Variety of materials used in making parts or finished product.
PACMW—
PACMX—
PACMY—
PACMZ—

It is evident at this point that the symbol is becoming long and cumbersome and if many more letters were added it would be in danger of becoming unwieldy. In practice, therefore, it is often customary to cut off the first letters of the symbol when they are not needed to identify the subject matter. In the case of materials, for instance, it is frequently wise to cut off the first four letters, for in most places where the symbol for material is used there is little danger of confusing it with any other.

It is also desirable to indicate in some way whether material is purchased or is made in the factory. This can be done by inserting an "S" in the symbol for material after the "M" for material, and before the letter indicating the class of material, setting it off by dashes or parentheses marks, as: PACM-S-P or PACM(S)P. If the first four letters are dropped in use, then the "S" can be prefixed directly to the remainder of the symbol. If there is any danger of confusion between the prefix "S" denoting "stores," or purchased materials, and the "S" indicating supplies in the abbreviated symbol, the dash after the "S" indicating stores may be retained.

According to the abbreviated form of the symbol, supplies might be classified and symbolized as follows:

S-SA—
S-SB—
S-SC—
S-SD—
S-SE—
S-SF—Office supplies.
S-SG—
S-SH—
S-SJ—Janitors' supplies.
S-SK—
S-SL—Lubricants
S-SM—
S-SN—
S-SP—Printed forms.
S-SR—Repair parts.
S-SS—
S-ST—
S-SV—Supplies used for a variety of purposes.
S-SW—
S-SX—
S-SY—
S-SZ—

It is now necessary to turn back to the fixed assets once more and briefly outline some of the principal subdivisions:

PAFA—
PAFB—Buildings.
PAFC—
PAFD—
PAFE—Equipment.
PAFF—
PAFG—Goodwill.
PAFH—
PAFJ—
PAFK—
PAFL—Land.
PAFM—
PAFN—
PAFP—
PAFR—Records (standardized and permanent).
PAFS—
PAFT—
PAFV—
PAFW—
PAFX—
PAFY—
PAFZ—

The division of equipment is of particular interest to the factory executive because the equipment of a manufacturing concern comes under his control.

PAFEA—
PAFEB—
PAFEC—
PAFED—
PAFEE—
PAFEF—Furniture and fixtures.
PAFEG—
PAFEH—
PAFEJ—
PAFEK—
PAFEL—
PAFEM—Machinery.
PAFEN—
PAFEP—
PAFER—
PAFES—
PAFET—Tools.
PAFEV—
PAFEW—
PAFEX—
PAFEY—
PAFEZ—

Each of these groups of equipment should be still further divided on some logical basis until the separate units are reached. These can best be symbolized within the ultimate group by adding consecutive numbers, and in this way the symbol is obtained which appears on the plant register.

The permanent value of the recorded standards.—All of subdivisions are quite what would normally be expected. The groups—PAFR—Records, which is shown under the head of fixed assets, deserves some additional explanation. In this class is gathered together all those records of permanent character, such as the various standards which have previously been discussed, especially those for methods, operations, materials, and workers. In the case of materials and equipment the same symbol can be employed to identify both the thing itself and the record thereof which is made. In so far as methods and operations are concerned there is nothing tangible except the record of how they are to be performed.

It may seem unwise at first to include methods and operation standards as fixed assets, but a little careful analysis will reveal that there is nothing wrong with this, but rather that it is fundamentally right. If the standards have been set after careful study of the process and scientific research to determine the best way of doing the work, they represent an addition to the permanent value of the plant just as truly as does a tool whose design and procurement enables the factory to do better or faster work. There would be no hesitation in adding the value of the tool to the plant inventory in one way or another and there should be no hesitation in adding the value of the standards. As new methods are developed it is necessary to write off the value placed upon the former ones, but this new action offers no greater problems than do depreciation and obsolescence. Extreme conservatism may dictate the evaluation of such assets as $1, simply to bring them on to the balance sheet. In any case, however, they are properly classed as assets of the company. Several instances prove that they have tangible value in case of the sale of the business.

The specifications of the workers fall in much the same class as the specifications of the operations, although the workers are physical entities like materials and equipment. As it is usually not convenient nor profitable to try to symbolize the workers themselves, it is ordinarily most satisfactory to include their specifications along with the other standards which have just been discussed.

Included in these records, in addition to employee specifications, are the standard practice instructions, instruction cards, route charts, and the organization manual. They may be subdivided as follows:

PAFRA—
PAFRB—
PAFRC—
PAFRD—
PAFRE—Employee specifications.
PAFRF—
PAFRG—
PAFRH—
PAFRJ—Instruction cards.
PAFRK—
PAFRL—
PAFRM—Manual, organization.
PAFRN—
PAFRP—
PAFRR—Route charts.
PAFRS—Standard practice instructions.
PAFRT—
PAFRV—
PAFRW—
PAFRX—
PAFRY—
PAFRZ—

The employee specifications, instruction cards, organization manual, and standard practice instructions should be further classified according to departments, and then into smaller groups. A suggested symbolized classification for departments has been presented in Chapter III. The route charts, on the other hand, should be classified according to the kind of part or product to be fabricated, and hence should follow the classification for materials.

Conclusion.—The question of the adequate classification and symbolization of the matter with which a company must work does not involve any fundamental principles, but enough has been given to indicate the complexity of the subject and its importance as one of the tools in the hands of the business executive and his associates to aid them in the accomplishing of their tasks. The task of preparing the classification is properly to be considered a part of the setting of the manufacturing standards. It should always be kept in mind, however, that a classification, to be thoroughly satisfactory, must embrace all phases of the business, for a company should be more than the sum of all its parts—it should be an organically whole unit.

References for Additional Reading.

Cartmell, M., "Stores and Material Control," Chapters VII-IX.
Farquhar, H. H., "Factory Storeskeeping," Chapter IX.
Lansburgh, R. H., "Industrial Management," Chapter XVII.
Thompson, C. B., "Scientific Management," pages 461-519.

CHAPTER XIX

THE DESIGN OF PRINTED FORMS

Purposes of this chapter.—

1. To consider the significance of the printed forms in the control of internal business operations.
2. To investigate the problem of how to design printed forms.

To some business men printed forms are the acme of the system which they have developed and which they feel to be all that could be desired, the visible evidence of their means of control. To others, printed forms are mere red tape, to be eliminated so far as possible.

To the theoretical student of business they are often a mere detail of no importance as compared with the great underlying principles on which the business structure is erected, while by only a few is their worth correctly evaluated and their place properly understood.

The real importance of printed forms.—Actually, printed forms are an important tool to be used in carrying on the routine work of the business, a serviceable aid in the utilization of standard methods of procedure. If they are correctly designed, they help very materially in saving time in the making of necessary records, in using those methods once they are made, in preventing mistakes and oversight, and in locating and correcting any which have occurred. They promote the development of good habits of work and discourage bad ones; they are very useful supplement to the standard practice instructions and instruction cards by means of which standards are recorded. They aid in the filing of data and in locating them when wanted; they facilitate the preparation of reports and increase the speed with which statements can be prepared. They are not in themselves a matter of principle, but they are a most useful aid in the control of current operations.

Reasons for the utility of printed forms.—The reasons for their utility are based on the observance of certain points which it is well to call to mind. When printed forms are employed, the same kind of information should always be put in the same place every time. This means that the habit will become established on the part of those who fill out any portion of the form of putting the data regularly in one place, and the custom of always looking for them in that place on the part of those who wish to use the information will become established. This results in less mental effort for all concerned and less likelihood of important details being overlooked. Unaccustomed blank spaces quickly strike the eye and the chances are that they are likely to receive immediate attention. It is much easier also to refer to specific places or columns in the preparation of standard instructions, and hence the utility of this means of recording standard methods is increased. Printed forms decrease labor and decrease fatigue, and their use is a distinct labor-saving device. When forms are printed a certain part of the desired information is already there, and the person who undertakes to fill it out needs so much less time as well as so much less energy for the completion of his tasks.

The arrangement of the spaces on the forms.—A proper arrangement of the data entered on the form brings the data which are needed for filing purposes to the top where they can be easily seen, and mistakes which are due to the necessity of looking for the filing symbols are reduced, if not wholly eliminated.

Defects in the design of forms.—All these various advantages are predicated on the forms being properly designed. In far too many instances they are not correctly laid out to fill the needs which they should meet. Spaces are not planned for various items of information which should go on them, the various spaces are ill arranged for easy utilization of the data which has been recorded thereon, or which is to be abstracted therefrom, filing symbols are located in various positions on the forms, and other technical faults appear which vitiate in large measure the benefits which might be obtained from satisfactorily planned forms.

Reasons for troubles with forms.—To a considerable extent such defects are due to a lack of training in the technique of form design on the part of the person who has this task to perform. To a much higher degree, however, the trouble is that the individual does not have that thorough knowledge of the methods of control which are employed in the plant and the uses to which the forms are to be put. Often the difficulties in these respects, which are encountered, are due to the fact that anybody who wishes a form is allowed to design it. Hence, little or no consideration is given to the needs of other positions and functions for the information which the form is to record, and for its relation to the other forms with which it is to be filed. As a result, it too frequently happens, for example, that a material issue is designed to meet the needs of the shop and Planning Department, but no attention is paid to the fact that the Cost Department is also obliged to use it. Spaces are provided for quantities, but none for prices and values. Hence it is necessary to squeeze in these figures between the lines, and all too often some of them are overlooked, or quantities are entered as values. As a consequence, inventories and cost records are found to be incorrect, and frequently the forms are blamed when really the fault lies with the designer.

The control of the design of factory forms.—The production engineer is usually the best person to undertake the design of the forms which originate in the factory. Fundamentally, the forms are a part of the manufacturing standards as represented by the standard practice instructions. It will be recalled that one group of standard practice instructions is to explain the use of the various forms which pass from one position to another. Such instructions should normally be prepared at the time when the forms are designed. The man who is equipped to do one of these tasks is usually capable of doing the other also. It is essential, of course, that he should have considerable familiarity with the use of the forms outside of the factory before he undertakes their design or the preparation of standard practice instructions to accompany them.

As forms are used to convey information between the principal functions of a business as well as among their several subdivisions, some one who is able to survey the needs of the company as a whole and supervise the design of the forms from such a standpoint is needed. The general manager, acting through a staff assistant, is usually the one best qualified to do this. In many concerns there is enough to keep an assistant to the general manager busy all the time with the problems which are involved in the setting of standards, in so far as more than one department or major function of the business is concerned. Such a man should be a well-trained management engineer and should have general supervision over such matters as the organization manual, the symbolized classification, standard practice instructions, the design of printed forms, etc. His function should be largely one of coördination and he should prepare for the general manager such data as the latter needs to issue orders in regard to these matters affecting more than one executive. Such an individual should leave to the persons most interested the handling of the details so far as possible, for they are the ones who know best what is needed and how to set about meeting the needs. In so far as the factory is concerned, this means the manufacturing standards department.

While the illustrations which follow are largely drawn from the forms of primary interest to the factory, what is said applies equally well to forms for the use of any section of the business. In the actual design of a form there are a number of technical details which should receive consideration, especially if the form is to be economical in cost. Most of these points are simple, but frequently they are overlooked and the company suffers in consequence.

The size and shape of the form.—The size and shape of the form must be decided upon at the start. It is essential, of course, to have sufficient space for all the data which it is necessary to record. There are few faults more serious than to leave so little room that figures run over from one column to another, or from one space to another, for errors in use are almost sure to result. At the same time it must be remembered that paper costs money, and that large forms cost more to print than do small ones.

It is far more important, however, to give consideration to the shape of the form than to the number of square inches of space which it may contain. There are two reasons for this. In the first place, paper and card stock come in certain commercially standardized sizes. If forms are cut to standard dimensions these commercial sizes of stock can be utilized with a minimum amount of waste. If non-standard sizes of forms are designed the waste of paper is heavy, sometimes running to almost 50 per cent of the stock purchased. The loss under these circumstances is large and continuous so long as the form is used. In the second place, standard filing cases and covers are available in which standard size forms may be filed. If odd sizes are insisted upon, special filing equipment must be obtained and special equipment costs far more than the standard kind.

The more common standard sizes for forms are:

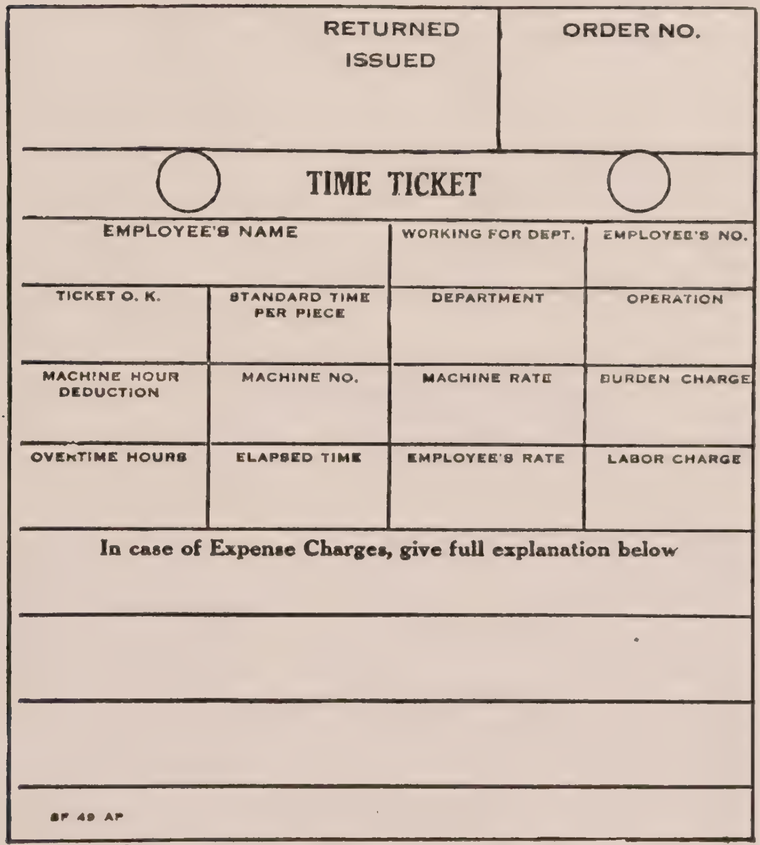
3″ x 5″	and	5″ x 3″
4″ x 6″	"	6″ x 4″
5″ x 8″	"	8″ x 5″
6″ x 9″	"	9″ x 6″
	8½″ x 11″	
	17 ″ x 22″	
	22 ″ x 34″	

These sizes or some multiple or division of these sizes should be used in design of forms so far as possible. It should be noted that two rows of the 4½″ x 4″ forms can be filed in a 5″ x 8″ file, and that the 9″ x 8″ form when folded twice is also 4½″ x 4″ and can be filed with the smaller forms in the same sized file.

The arrangement of the spaces on the form.—Once the size and shape of the form has been determined the next consideration is the arrangement of the spaces on the form itself. There are two points to be borne in mind here—the arrangement from the standpoint of the particular form itself and the arrangement of the form in respect to other forms with which it is to be used. These points are well illustrated in Figure 59. In Figure 59 it will be noted, for example, that it is necessary to extend the elapsed time by the employee's rate to obtain the labor charge, and by the machine rate to get the earned burden charge. These spaces are so placed that in the case of the labor cost calculation all the elements are on one line, and for the computation of the burden charge two of the elements are on one line and only one on a different line—the line just below. It is often possible in such a case, which occurs very frequently, to arrange the spaces like this:

Time Returned...........
Time Issued ....Machine Number.........
Elapsed Time............Machine Rate............Burden Charge...........
Employee's Rate..........Employee's Number ......
Labor Charge............

Such a plan allows one computation to be made horizontally and the other vertically, and also brings into juxtaposition the "machine number" and the "employee's number," data which are essential in fixing the machine rate and rate of pay, respectively.



	RETURNED ISSUED		ORDER NO.
	TIME TICKET		
EMPLOYEE'S NAME		WORKING FOR DEPT.	EMPLOYEE'S NO.
TICKET O. K.	STANDARD TIME PER PIECE	DEPARTMENT	OPERATION
MACHINE HOUR DEDUCTION	MACHINE NO.	MACHINE RATE	BURDEN CHARGE
OVERTIME HOURS	ELAPSED TIME	EMPLOYEE'S RATE	LABOR CHARGE

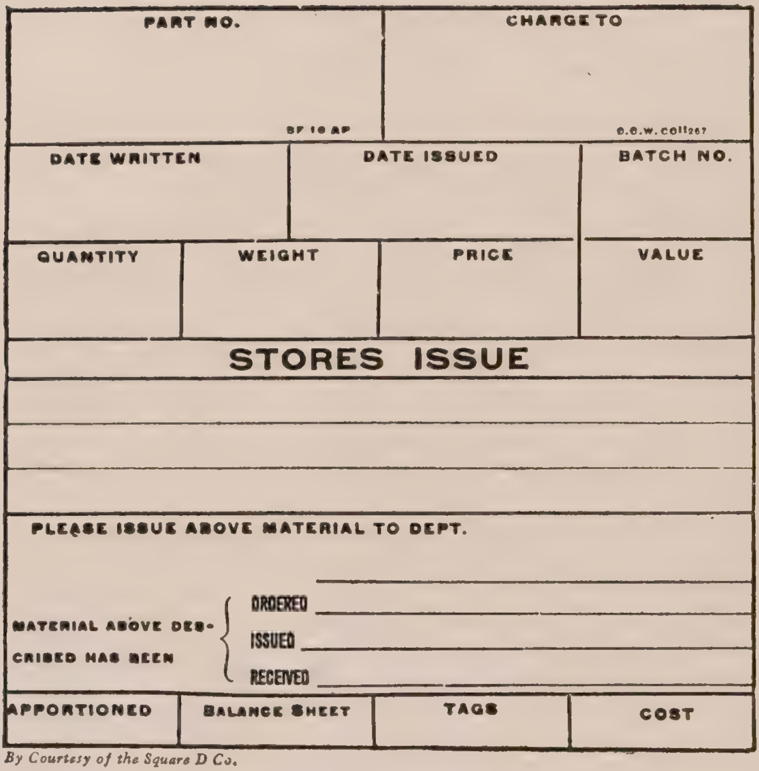
In case of Expense Charges, give full explanation below

SF 49 AP

By Courtesy of the Square D Co.

Fig. 59.—Time Ticket.

In Figures 60A, B, C and D, this same point is well illustrated where the quantity and weight, price and value spaces are all on one line, and hence are most easily available for calculations.



PART NO. SF 10 AP		**CHARGE TO** D.C.W. CO. 267	
DATE WRITTEN	**DATE ISSUED**		**BATCH NO.**
QUANTITY	**WEIGHT**	**PRICE**	**VALUE**

STORES ISSUE

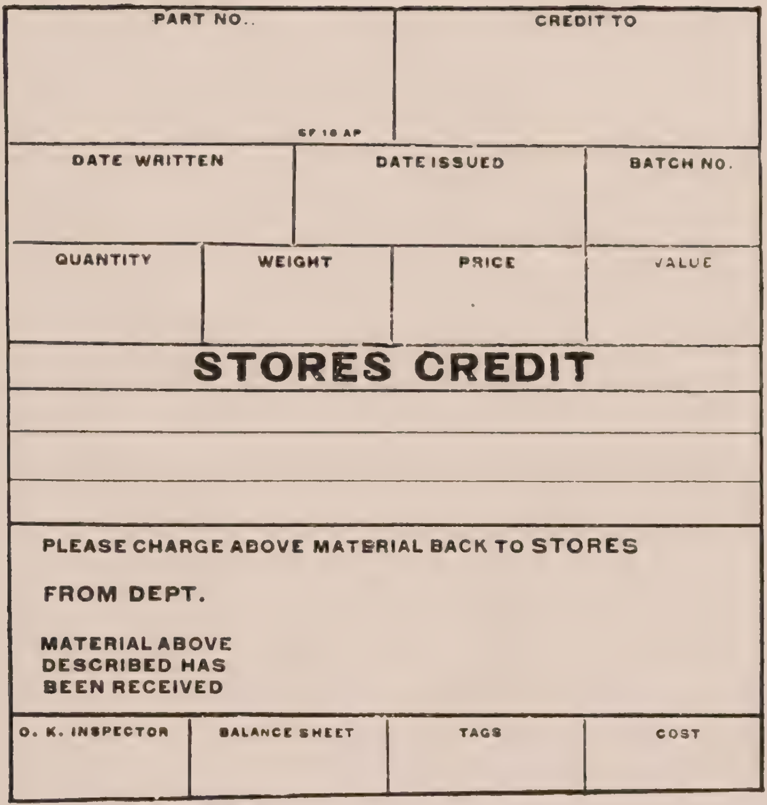
PLEASE ISSUE ABOVE MATERIAL TO DEPT. ____________________

MATERIAL ABOVE DESCRIBED HAS BEEN { **ORDERED** ____________________
ISSUED ____________________
RECEIVED ____________________

APPORTIONED	**BALANCE SHEET**	**TAGS**	**COST**

By Courtesy of the Square D Co.

Fig. 60A.—Stores Issue.



PART NO..	CREDIT TO

SF 18 AP

DATE WRITTEN	DATE ISSUED	BATCH NO.

QUANTITY	WEIGHT	PRICE	VALUE

STORES CREDIT

PLEASE CHARGE ABOVE MATERIAL BACK TO STORES

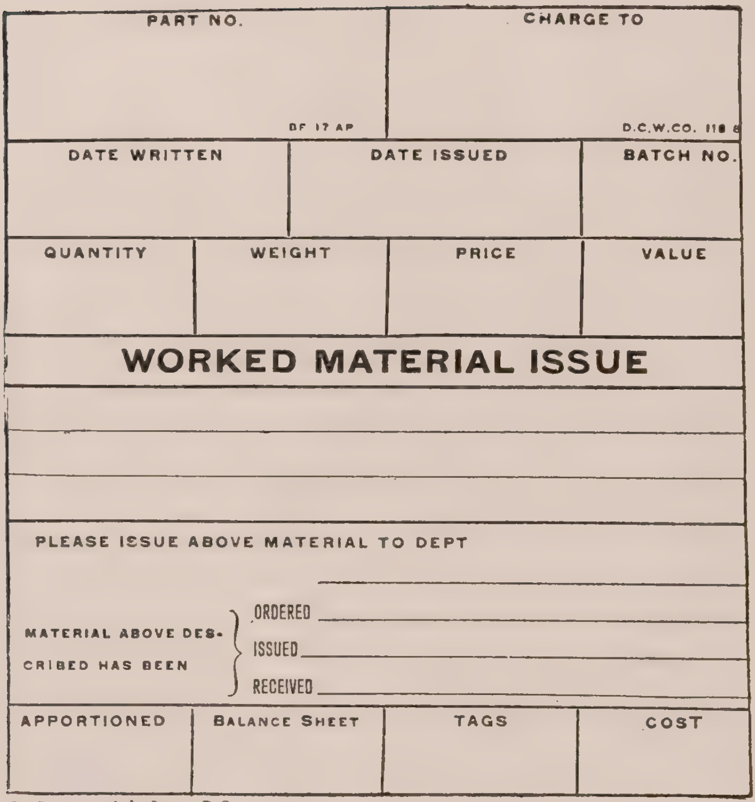
FROM DEPT.

MATERIAL ABOVE
DESCRIBED HAS
BEEN RECEIVED

O. K. INSPECTOR	BALANCE SHEET	TAGS	COST

By Courtesy of the Square D Co.

Fig. 60B.—Stores Credit Slip.



PART NO. DF 17 AP	CHARGE TO D.C.W.CO. 118

DATE WRITTEN	DATE ISSUED	BATCH NO.

QUANTITY	WEIGHT	PRICE	VALUE

WORKED MATERIAL ISSUE

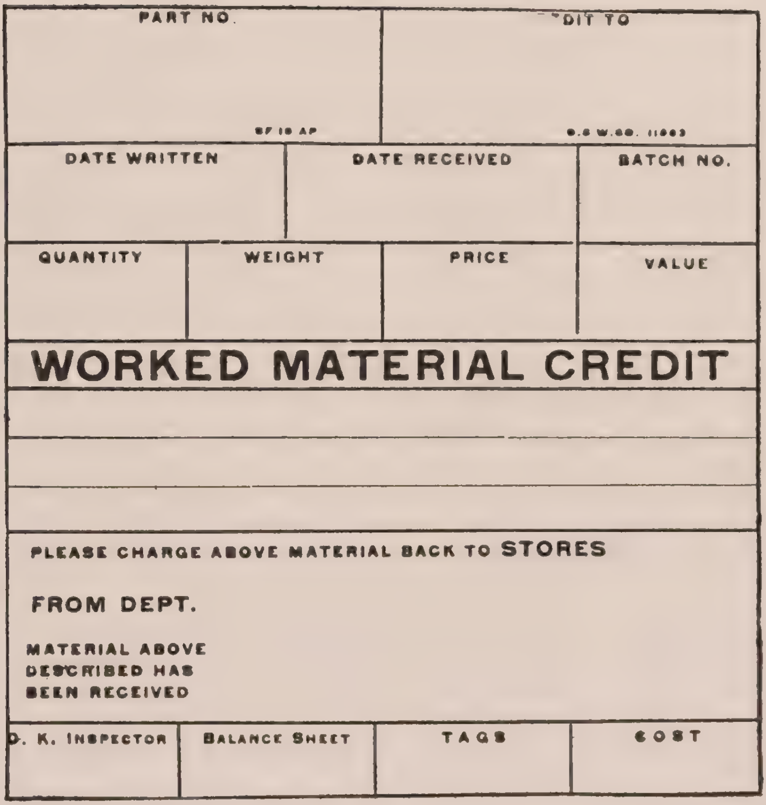
PLEASE ISSUE ABOVE MATERIAL TO DEPT ____________

MATERIAL ABOVE DESCRIBED HAS BEEN
- ORDERED ____________
- ISSUED ____________
- RECEIVED ____________

APPORTIONED	BALANCE SHEET	TAGS	COST

By Courtesy of the Square D Co.

Fig. 60C.—Worked Material Issue.



PART NO. 87 10 AP	DIT TO D.S W.CO. 11663

DATE WRITTEN	DATE RECEIVED	BATCH NO.

QUANTITY	WEIGHT	PRICE	VALUE

WORKED MATERIAL CREDIT

PLEASE CHARGE ABOVE MATERIAL BACK TO STORES

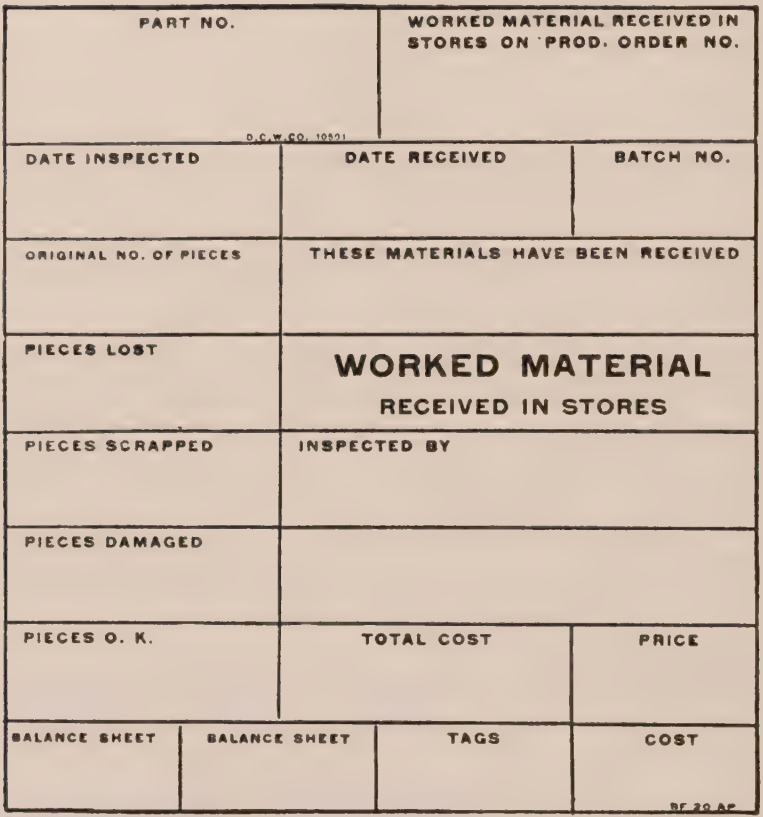
FROM DEPT.

MATERIAL ABOVE
DESCRIBED HAS
BEEN RECEIVED

O. K. INSPECTOR	BALANCE SHEET	TAGS	COST

By Courtesy of the Square D Co.

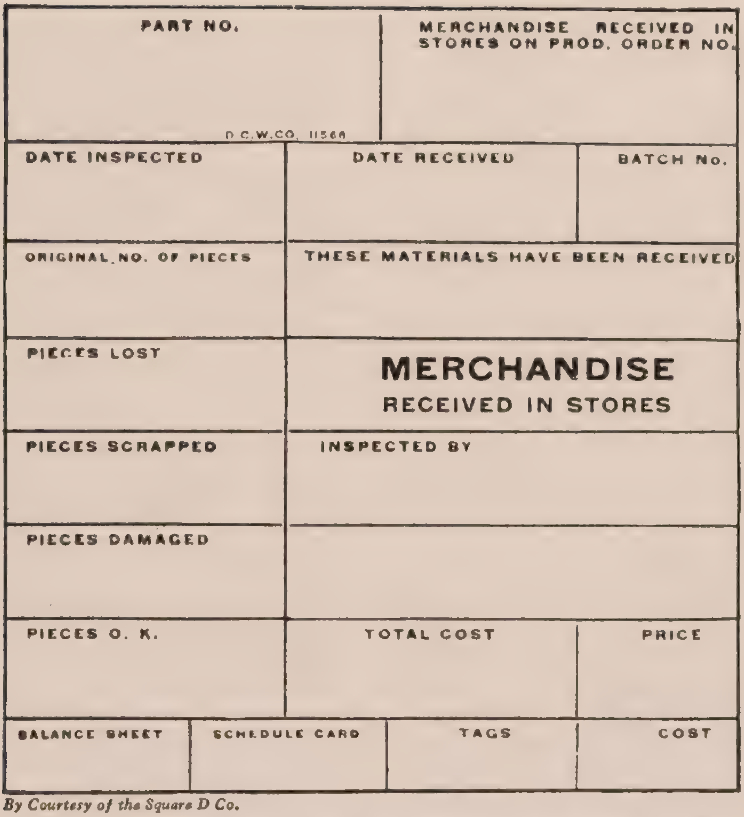
Fig. 60D.—Worked Material Credit Slip.



PART NO. D.C.W.CO. 10901		WORKED MATERIAL RECEIVED IN STORES ON PROD. ORDER NO.	
DATE INSPECTED	DATE RECEIVED		BATCH NO.
ORIGINAL NO. OF PIECES	THESE MATERIALS HAVE BEEN RECEIVED		
PIECES LOST	**WORKED MATERIAL** RECEIVED IN STORES		
PIECES SCRAPPED	INSPECTED BY		
PIECES DAMAGED			
PIECES O. K.	TOTAL COST		PRICE
BALANCE SHEET	BALANCE SHEET	TAGS	COST SF 20 AP

By Courtesy of the Square D Co.

Fig. 60E.—Worked Material Received in Stores Slip.

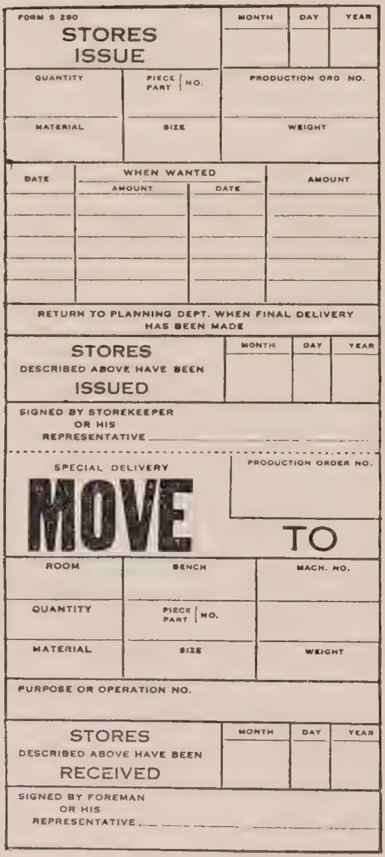


PART NO. D.C.W.CO. 11568	MERCHANDISE RECEIVED IN STORES ON PROD. ORDER NO.		
DATE INSPECTED	DATE RECEIVED	BATCH No.	
ORIGINAL NO. OF PIECES	THESE MATERIALS HAVE BEEN RECEIVED		
PIECES LOST	**MERCHANDISE** RECEIVED IN STORES		
PIECES SCRAPPED	INSPECTED BY		
PIECES DAMAGED			
PIECES O. K.	TOTAL COST	PRICE	
BALANCE SHEET	SCHEDULE CARD	TAGS	COST

By Courtesy of the Square D Co.

Fig. 60F.—Merchandise Received in Stores Slip.

The arrangement of filing data.—It is also quite essential that forms be so arranged as to facilitate filing and to promote their easy location in a file when wanted. It has been found that the upper right-hand corner of the form is the best place for filing data; next to it, the space just below or to the left, then the upper left-hand corner. Hence, it is desirable to have the symbol of the principal subdivision, under which the form



FORM S 280

STORES ISSUE

MONTH | DAY | YEAR

QUANTITY | PIECE PART NO. | PRODUCTION ORD NO.

MATERIAL | SIZE | WEIGHT

DATE | WHEN WANTED AMOUNT | DATE | AMOUNT

RETURN TO PLANNING DEPT. WHEN FINAL DELIVERY HAS BEEN MADE

STORES DESCRIBED ABOVE HAVE BEEN ISSUED | MONTH | DAY | YEAR

SIGNED BY STOREKEEPER OR HIS REPRESENTATIVE

SPECIAL DELIVERY

MOVE

PRODUCTION ORDER NO.

TO

ROOM | BENCH | MACH. NO.

QUANTITY | PIECE PART NO.

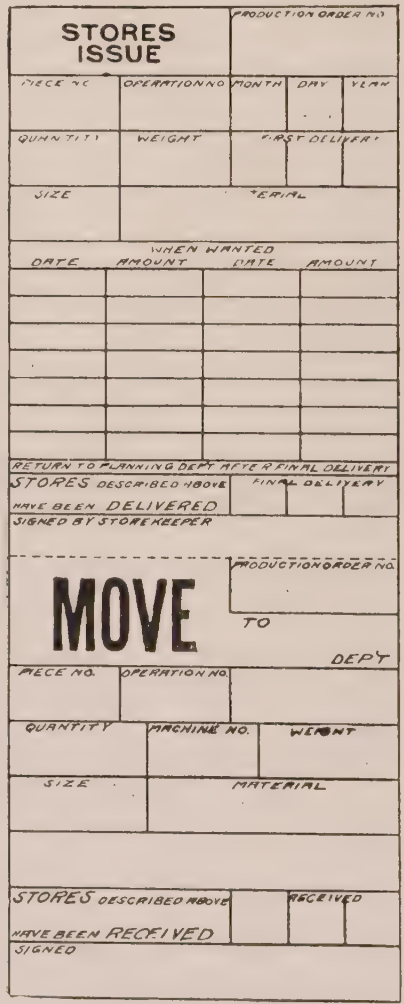
MATERIAL | SIZE | WEIGHT

PURPOSE OR OPERATION NO.

STORES DESCRIBED ABOVE HAVE BEEN RECEIVED | MONTH | DAY | YEAR

SIGNED BY FOREMAN OR HIS REPRESENTATIVE

Fig. 61A—1 (old).



STORES ISSUE

PRODUCTION ORDER NO

PIECE NO | OPERATION NO | MONTH | DAY | YEAR

QUANTITY | WEIGHT | FIRST DELIVERY

SIZE | MATERIAL

WHEN WANTED

DATE | AMOUNT | DATE | AMOUNT

RETURN TO PLANNING DEPT AFTER FINAL DELIVERY

STORES DESCRIBED ABOVE HAVE BEEN DELIVERED | FINAL DELIVERY

SIGNED BY STOREKEEPER

MOVE

PRODUCTION ORDER NO.

TO

DEPT

PIECE NO. | OPERATION NO.

QUANTITY | MACHINE NO. | WEIGHT

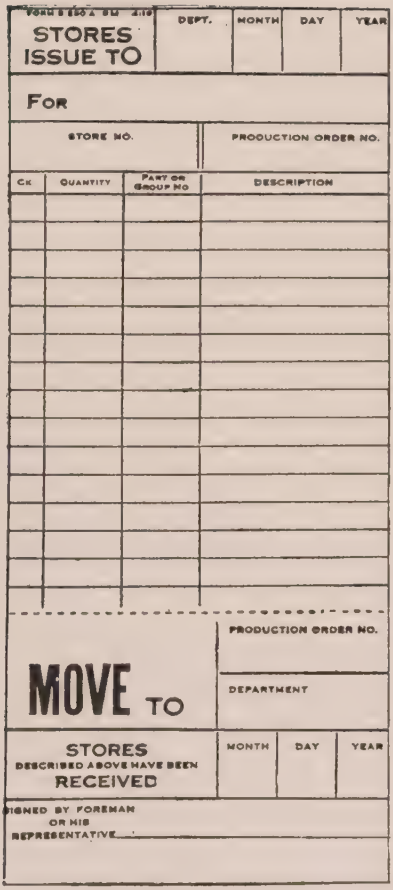
SIZE | MATERIAL

STORES DESCRIBED ABOVE HAVE BEEN RECEIVED | RECEIVED

SIGNED

Fig. 61A—2 (new).

Stores Issue



STORES ISSUE TO

DEPT.

MONTH

DAY

YEAR

FOR

STORE NO.

PRODUCTION ORDER NO.

CK	QUANTITY	PART OR GROUP NO	DESCRIPTION

MOVE TO

PRODUCTION ORDER NO.

DEPARTMENT

STORES DESCRIBED ABOVE HAVE BEEN RECEIVED

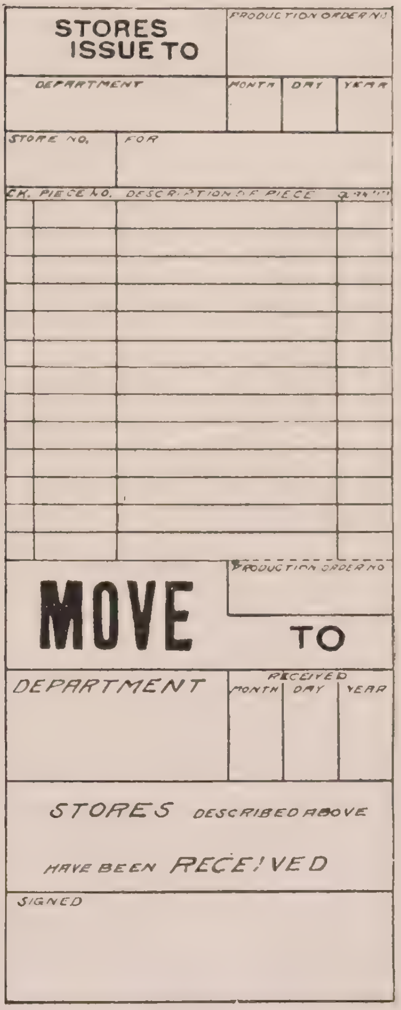
MONTH

DAY

YEAR

SIGNED BY FOREMAN OR HIS REPRESENTATIVE

Fig. 61B—1 (old).



STORES ISSUE TO

PRODUCTION ORDER NO.

DEPARTMENT

MONTH

DAY

YEAR

STORE NO.

FOR

CK.	PIECE NO.	DESCRIPTION OF PIECE	QUAN'TY

MOVE TO

PRODUCTION ORDER NO

DEPARTMENT

RECEIVED

MONTH

DAY

YEAR

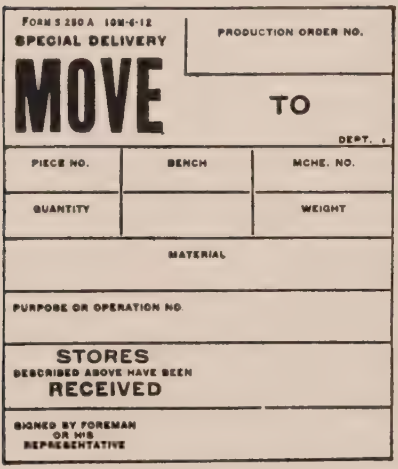
STORES DESCRIBED ABOVE HAVE BEEN RECEIVED

SIGNED

Fig. 61B—2 (new).

Group Issue.

is to be filed, located in the upper right-hand corner of the form, the symbol of the next subdivision just below, etc. Figure 60 shows this very well, for the filing symbols are, first, order number ("charge to," "credit to," etc.), and second "batch No." It should also be noted in this connection that all filing information on all these forms, which are to be filed together, comes in the same place on each form. This is of prime importance, for, if a drawing number, or quantity, or some other figure or symbol were located on one form where the order number space is on the others, the time necessary to file all forms would be increased and the likelihood of error multiplied.



FORM S 250 A 10M-6-12
SPECIAL DELIVERY
MOVE
PRODUCTION ORDER NO.
TO
DEPT.

PIECE NO.	BENCH	MCHE. NO.
QUANTITY		WEIGHT

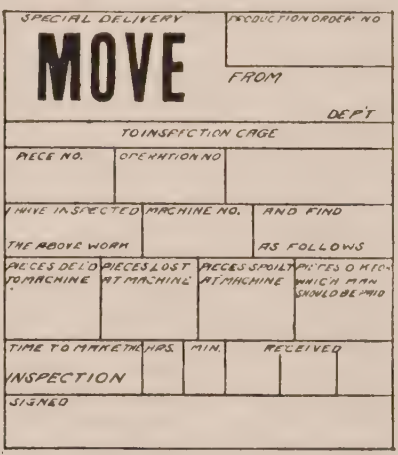
MATERIAL

PURPOSE OR OPERATION NO.

STORES
DESCRIBED ABOVE HAVE BEEN
RECEIVED

SIGNED BY FOREMAN
OR HIS
REPRESENTATIVE

Fig. 61C—1.



SPECIAL DELIVERY
MOVE
PRODUCTION ORDER NO
FROM
DEP'T
TO INSPECTION CAGE

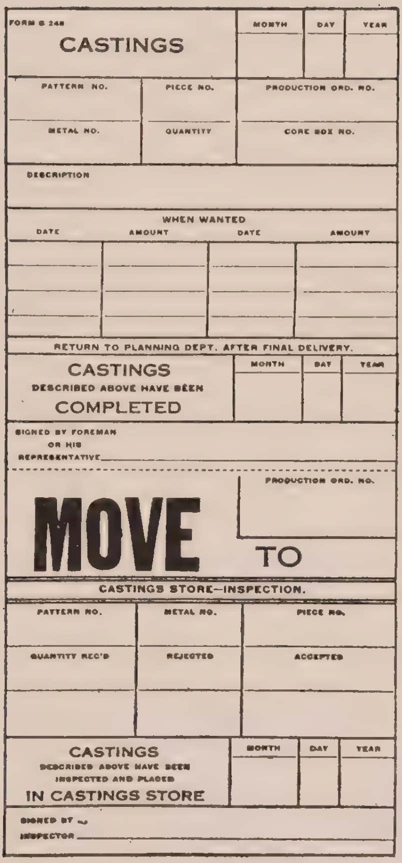
PIECE NO.	OPERATION NO		
I HAVE INSPECTED THE ABOVE WORK	MACHINE NO.	AND FIND AS FOLLOWS	
PIECES DEL'D TO MACHINE	PIECES LOST AT MACHINE	PIECES SPOILT AT MACHINE	PIECES O K FOR WHICH MAN SHOULD BE PAID
TIME TO MAKE THE INSPECTION	HRS.	MIN.	RECEIVED

SIGNED

Fig. 61C—2.

Special Move Order Stores.

An interesting example of the way in which forms are laid out without attention to this point, and of the manner in which they may be designed to eliminate this trouble is given in Figure 61. Particular attention is called to the location of the production order number, piece number, and operation number spaces, for the information recorded therein is that which is used for filing purposes in the order named. It will be noted that the arrangement, even in the new forms, is not that which was described as the ideal, although it closely approximates to



FORM G 248

CASTINGS

MONTH	DAY	YEAR		
PATTERN NO.	PIECE NO.	PRODUCTION ORD. NO.		
METAL NO.	QUANTITY	CORE BOX NO.		

DESCRIPTION

WHEN WANTED

DATE	AMOUNT	DATE	AMOUNT

RETURN TO PLANNING DEPT. AFTER FINAL DELIVERY.

CASTINGS
DESCRIBED ABOVE HAVE BEEN
COMPLETED

MONTH	DAY	YEAR

SIGNED BY FOREMAN
OR HIS
REPRESENTATIVE__________

MOVE TO

PRODUCTION ORD. NO.

CASTINGS STORE—INSPECTION.

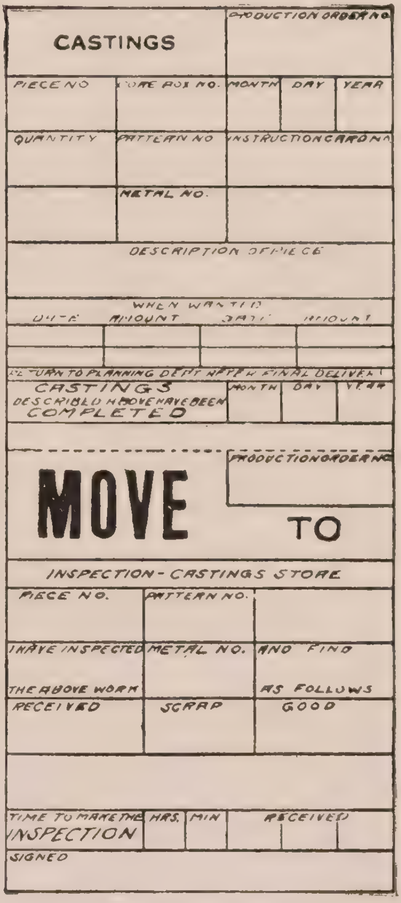
PATTERN NO.	METAL NO.	PIECE NO.
QUANTITY REC'D	REJECTED	ACCEPTED

CASTINGS
DESCRIBED ABOVE HAVE BEEN
INSPECTED AND PLACED
IN CASTINGS STORE

MONTH	DAY	YEAR

SIGNED BY
INSPECTOR__________

Fig. 61D—1 (old).



CASTINGS

PRODUCTION ORDER NO.

PIECE NO	CORE BOX NO.	MONTH	DAY	YEAR
QUANTITY	PATTERN NO	INSTRUCTION CARD NO.		
	METAL NO.			

DESCRIPTION OF PIECE

WHEN WANTED

DATE	AMOUNT	DATE	AMOUNT

RETURN TO PLANNING DEPT AFTER FINAL DELIVERY

CASTINGS
DESCRIBED ABOVE HAVE BEEN
COMPLETED

MONTH	DAY	YEAR

MOVE TO

PRODUCTION ORDER NO.

INSPECTION - CASTINGS STORE

PIECE NO.	PATTERN NO.	
I HAVE INSPECTED THE ABOVE WORK	METAL NO.	AND FIND AS FOLLOWS
RECEIVED	SCRAP	GOOD

TIME TO MAKE THE INSPECTION	HRS.	MIN	RECEIVED

SIGNED

Fig. 61D—2 (new).

Castings Order.

it and by some people may be considered preferable to the first one presented. The words printed in the upper left-hand corner do not have the filing value of the spaces just below them. The scheme which has been followed in this instance is to put the most important symbol in the upper right-hand corner and then place the spaces for the subdivision thereof on the second line in order from left to right. The forms which are shown are split in two on the dotted line when put into use, and all the parts are later assembled in one file. As some or all of these forms shown in this figure are used for a single order, a little idea of the complexity of which may be gained from the number and variety of forms illustrated.

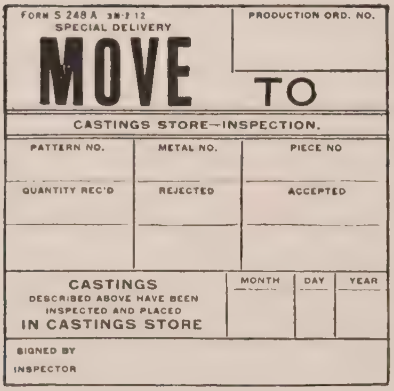

FORM S 248 A 3M-2-12
SPECIAL DELIVERY
MOVE
PRODUCTION ORD. NO.
TO
CASTINGS STORE—INSPECTION.
PATTERN NO.
METAL NO.
PIECE NO
QUANTITY REC'D
REJECTED
ACCEPTED
CASTINGS
DESCRIBED ABOVE HAVE BEEN
INSPECTED AND PLACED
IN CASTINGS STORE
MONTH
DAY
YEAR
SIGNED BY
INSPECTOR

Fig. 61E—1 (old).

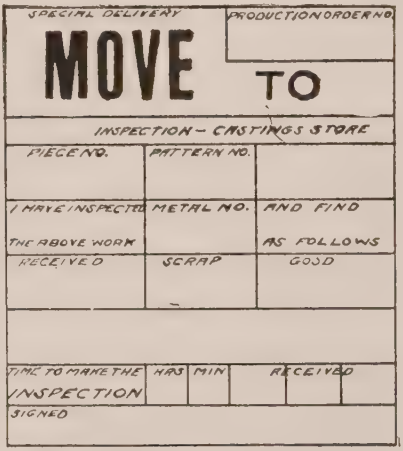
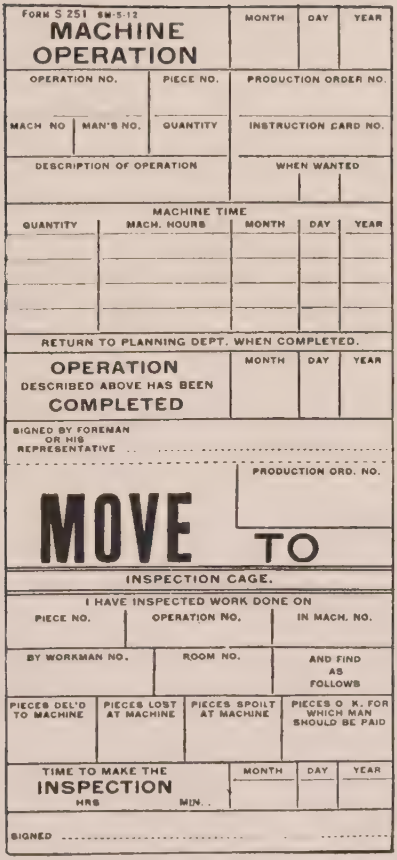

SPECIAL DELIVERY
MOVE
PRODUCTION ORDER NO.
TO
INSPECTION—CASTINGS STORE
PIECE NO.
PATTERN NO.
I HAVE INSPECTED
THE ABOVE WORK
METAL NO.
AND FIND
AS FOLLOWS
RECEIVED
SCRAP
GOOD
TIME TO MAKE THE
INSPECTION
HRS
MIN
RECEIVED
SIGNED

Fig. 61E—2 (new).

Special Move Order—Castings.

The preparation of groups of forms by duplicating devices.—The necessity of filing forms together after they have been used is only one reason for having spaces for the identical information located in the same position on a form. In Figure 62 are shown five different forms which it is possible to make out together by using carbon paper in respect to the five following details: (1) order number, (2) batch number, (3) part number, (4) machine number, and (5) operation number. This is possible only because the spaces for these data have



FORM S 251 8M-5-12

MACHINE OPERATION

MONTH | DAY | YEAR

OPERATION NO. | PIECE NO. | PRODUCTION ORDER NO.

MACH NO | MAN'S NO. | QUANTITY | INSTRUCTION CARD NO.

DESCRIPTION OF OPERATION | WHEN WANTED

MACHINE TIME				
QUANTITY	MACH. HOURS	MONTH	DAY	YEAR

RETURN TO PLANNING DEPT. WHEN COMPLETED.

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED | MONTH | DAY | YEAR

SIGNED BY FOREMAN OR HIS REPRESENTATIVE ....

MOVE TO | PRODUCTION ORD. NO.

INSPECTION CAGE.

I HAVE INSPECTED WORK DONE ON

PIECE NO. | OPERATION NO. | IN MACH. NO.

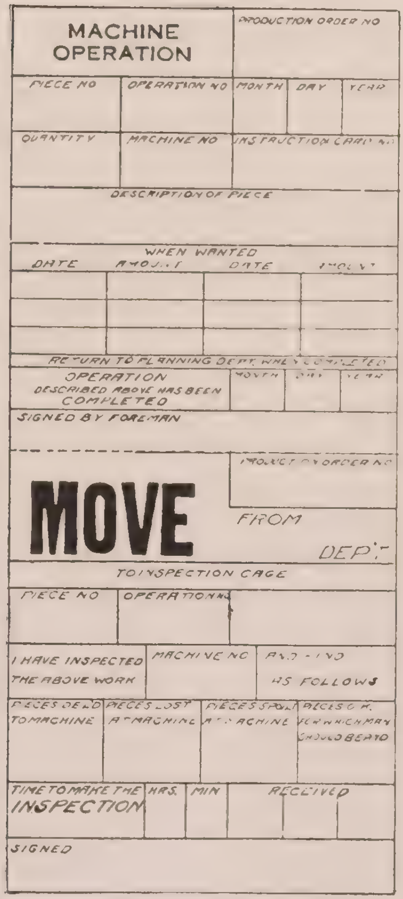
BY WORKMAN NO. | ROOM NO. | AND FIND AS FOLLOWS

PIECES DEL'D TO MACHINE | PIECES LOST AT MACHINE | PIECES SPOILT AT MACHINE | PIECES O. K. FOR WHICH MAN SHOULD BE PAID

TIME TO MAKE THE INSPECTION HRS MIN. . | MONTH | DAY | YEAR

SIGNED ....

Fig. 61F—1 (old).



MACHINE OPERATION | PRODUCTION ORDER NO

PIECE NO | OPERATION NO | MONTH | DAY | YEAR

QUANTITY | MACHINE NO | INSTRUCTION CARD NO

DESCRIPTION OF PIECE

WHEN WANTED			
DATE	AMOUNT	DATE	AMOUNT

RETURN TO PLANNING DEPT. WHEN COMPLETED

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED | MONTH | DAY | YEAR

SIGNED BY FOREMAN

MOVE | PRODUCTION ORDER NO

FROM DEP'T

TO INSPECTION CAGE

PIECE NO | OPERATION NO

I HAVE INSPECTED THE ABOVE WORK | MACHINE NO | AND FIND AS FOLLOWS

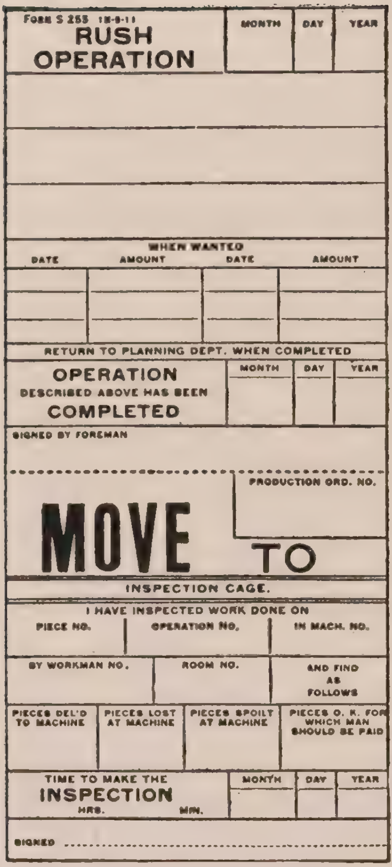
PIECES DEL'D TO MACHINE | PIECES LOST AT MACHINE | PIECES SPOILT AT MACHINE | PIECES O.K. FOR WHICH MAN SHOULD BE PAID

TIME TO MAKE THE INSPECTION | HRS. | MIN | RECEIVED

SIGNED

Fig. 61F—2 (new).

Machine Operation Order.



FORM S 255 12-8-11

RUSH OPERATION

MONTH | DAY | YEAR

WHEN WANTED

DATE | AMOUNT | DATE | AMOUNT

RETURN TO PLANNING DEPT. WHEN COMPLETED

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED

MONTH | DAY | YEAR

SIGNED BY FOREMAN

PRODUCTION ORD. NO.

MOVE TO

INSPECTION CAGE.

I HAVE INSPECTED WORK DONE ON

PIECE NO. | OPERATION NO. | IN MACH. NO.

BY WORKMAN NO. | ROOM NO. | AND FIND AS FOLLOWS

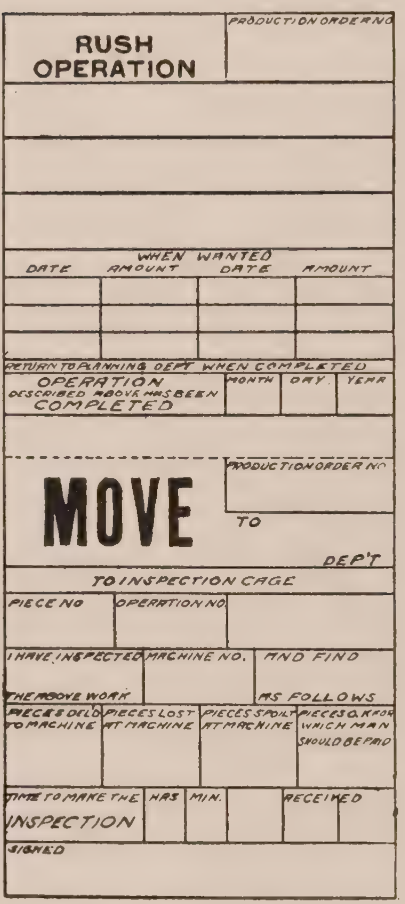
PIECES DEL'D TO MACHINE | PIECES LOST AT MACHINE | PIECES SPOILT AT MACHINE | PIECES O. K. FOR WHICH MAN SHOULD BE PAID

TIME TO MAKE THE INSPECTION HRS. MIN.

MONTH | DAY | YEAR

SIGNED

Fig. 61G—1 (old).



RUSH OPERATION

PRODUCTION ORDER NO

WHEN WANTED

DATE | AMOUNT | DATE | AMOUNT

RETURN TO PLANNING DEPT WHEN COMPLETED

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED

MONTH | DAY | YEAR

PRODUCTION ORDER NO

MOVE TO DEP'T

TO INSPECTION CAGE

PIECE NO | OPERATION NO

I HAVE INSPECTED THE ABOVE WORK | MACHINE NO. | AND FIND AS FOLLOWS

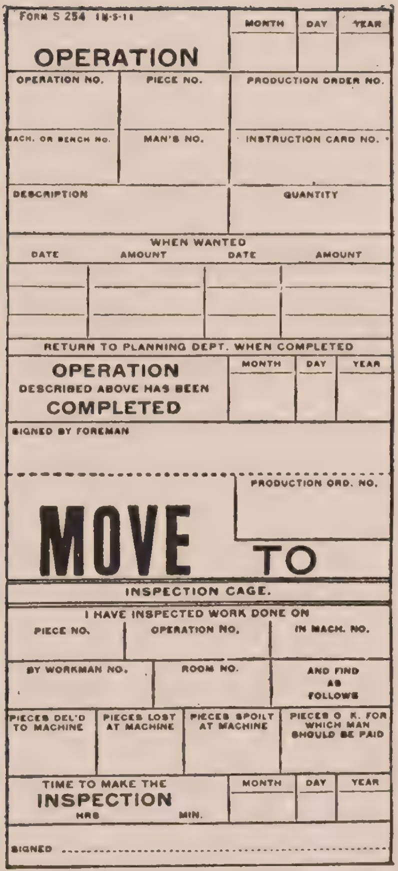
PIECES DEL'D TO MACHINE | PIECES LOST AT MACHINE | PIECES SPOILT AT MACHINE | PIECES O.K. FOR WHICH MAN SHOULD BE PAID

TIME TO MAKE THE INSPECTION | HRS | MIN. | RECEIVED

SIGNED

Fig. 61G—2 (new).

Rush Operation Order.



FORM S 254 1M-5-11

OPERATION

MONTH DAY YEAR

OPERATION NO.

PIECE NO.

PRODUCTION ORDER NO.

MACH. OR BENCH NO.

MAN'S NO.

INSTRUCTION CARD NO.

DESCRIPTION

QUANTITY

WHEN WANTED

DATE	AMOUNT	DATE	AMOUNT

RETURN TO PLANNING DEPT. WHEN COMPLETED

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED

MONTH DAY YEAR

SIGNED BY FOREMAN

PRODUCTION ORD. NO.

MOVE TO

INSPECTION CAGE.

I HAVE INSPECTED WORK DONE ON

PIECE NO.

OPERATION NO.

IN MACH. NO.

BY WORKMAN NO.

ROOM NO.

AND FIND AS FOLLOWS

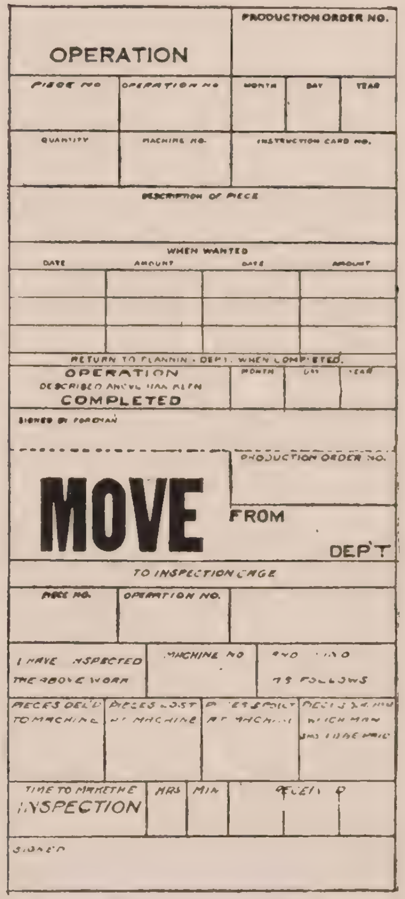
PIECES DEL'D TO MACHINE	PIECES LOST AT MACHINE	PIECES SPOILT AT MACHINE	PIECES O. K. FOR WHICH MAN SHOULD BE PAID

TIME TO MAKE THE INSPECTION HRS MIN.

MONTH DAY YEAR

SIGNED ....

Fig. 61H—1 (old).



OPERATION

PRODUCTION ORDER NO.

PIECE NO

OPERATION NO

MONTH DAY YEAR

QUANTITY

MACHINE NO.

INSTRUCTION CARD NO.

DESCRIPTION OF PIECE

WHEN WANTED

DATE	AMOUNT	DATE	AMOUNT

RETURN TO PLANNING DEPT. WHEN COMPLETED.

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED

MONTH DAY YEAR

SIGNED BY FOREMAN

PRODUCTION ORDER NO.

MOVE FROM DEP'T

TO INSPECTION CAGE

PIECE NO.

OPERATION NO.

I HAVE INSPECTED THE ABOVE WORK

MACHINE NO

AND FIND AS FOLLOWS

PIECES DEL'D TO MACHINE	PIECES LOST AT MACHINE	PIECES SPOILT AT MACHINE	PIECES O.K. FOR WHICH MAN SHOULD BE PAID

TIME TO MAKE THE INSPECTION HRS MIN

RECEIVED

SIGNED

Fig. 61H—2 (new).

Miscellaneous Operation Order.

been designed to register in the same place on each form. When the variety of forms is considered, the different uses to which they are put and the other kinds of information which it is necessary to record on each, it is evident that the problem is a difficult one to solve.

The use of a single form by several departments.—It was pointed out in one of the earlier paragraphs that attention must be given to the necessity of providing for the needs of departments which are to use a form other than the one which originates it. An illustration of how this may be done to advantage is shown in Figure 63. Three different departments use this form. It is made out in the Planning Department and is sent to the Stores Department as an order to issue the material called for. In many cases the latter department cannot issue the exact quantity of material requested. It is necessary, therefore, for it to record the quantity which is does issue and a column is provided for this purpose. The issue then returns to the Planning Department and is entered on the balance cards, and a column is provided so that each item may be checked as the quantity is entered on the balance card and the price on the issue. It is next sent to the Cost Department

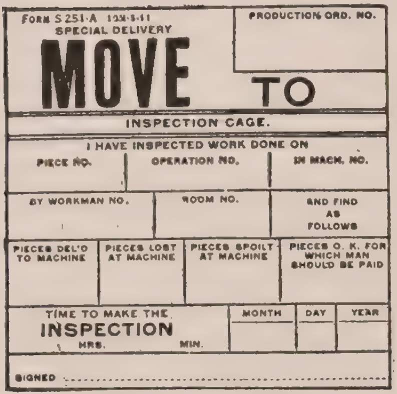

FORM S 251-A 12M-3-11
SPECIAL DELIVERY
MOVE TO
PRODUCTION ORD. NO.
INSPECTION CAGE.
I HAVE INSPECTED WORK DONE ON
PIECE NO. | OPERATION NO. | IN MACH. NO.
BY WORKMAN NO. | ROOM NO. | AND FIND AS FOLLOWS
PIECES DEL'D TO MACHINE | PIECES LOST AT MACHINE | PIECES SPOILT AT MACHINE | PIECES O. K. FOR WHICH MAN SHOULD BE PAID
TIME TO MAKE THE INSPECTION HRS. MIN. | MONTH | DAY | YEAR
SIGNED ....

Fig. 61I—1 (old).

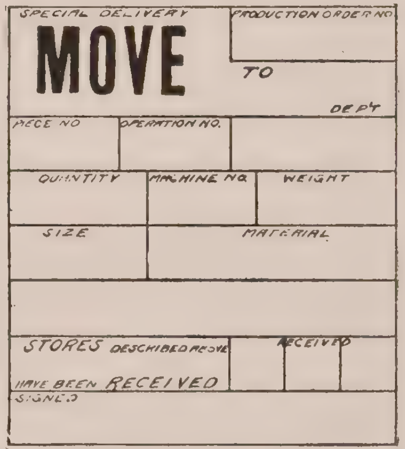
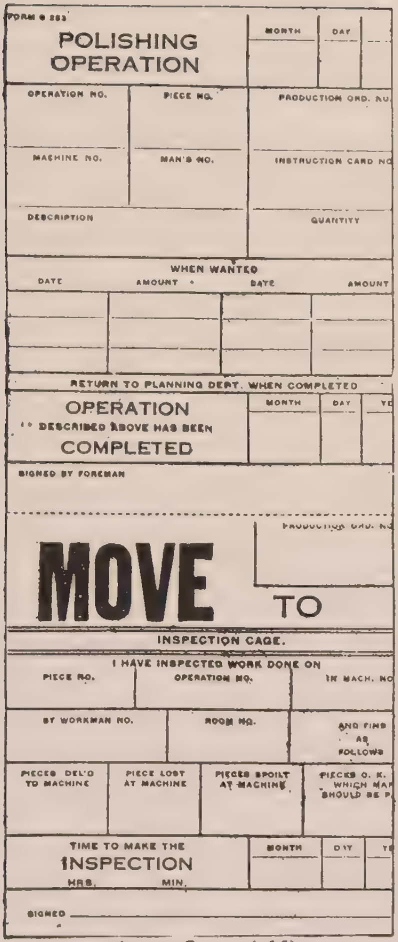

SPECIAL DELIVERY
MOVE
PRODUCTION ORDER NO
TO DEPT
PIECE NO | OPERATION NO.
QUANTITY | MACHINE NO | WEIGHT
SIZE | MATERIAL
STORES DESCRIBED ABOVE HAVE BEEN RECEIVED | RECEIVED
SIGNED

Fig. 61I—2 (new).

Special Order—Parts.



FORM # 283

POLISHING OPERATION

MONTH | DAY

OPERATION NO. | PIECE NO. | PRODUCTION ORD. NU

MACHINE NO. | MAN'S NO. | INSTRUCTION CARD NO

DESCRIPTION | QUANTITY

WHEN WANTED

DATE | AMOUNT | DATE | AMOUNT

RETURN TO PLANNING DEPT. WHEN COMPLETED

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED

MONTH | DAY | YE

SIGNED BY FOREMAN

MOVE

PRODUCTION ORD. NO

TO

INSPECTION CAGE.

I HAVE INSPECTED WORK DONE ON

PIECE NO. | OPERATION NO. | IN MACH. NO

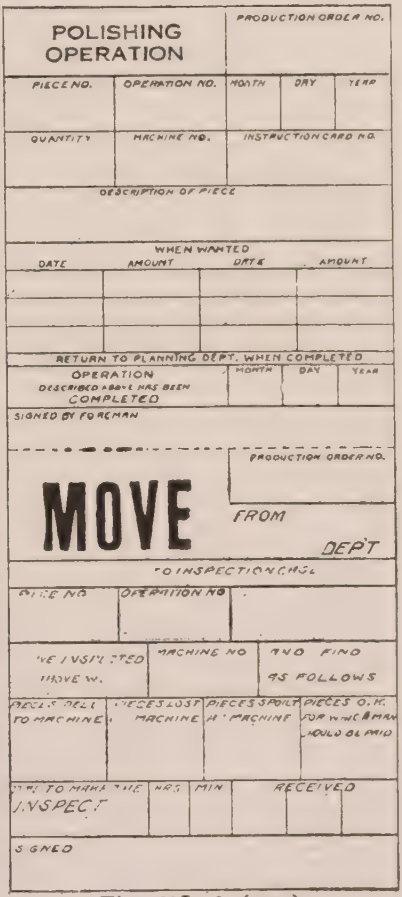
BY WORKMAN NO. | ROOM NO. | AND FIND AS FOLLOWS

PIECES DEL'D TO MACHINE | PIECE LOST AT MACHINE | PIECES SPOILT AT MACHINE | PIECES O. K. WHICH MA SHOULD BE P

TIME TO MAKE THE INSPECTION HRS. MIN.

MONTH | DAY | Y

SIGNED



POLISHING OPERATION

PRODUCTION ORDER NO.

PIECE NO. | OPERATION NO. | MONTH | DAY | YEAR

QUANTITY | MACHINE NO. | INSTRUCTION CARD NO.

DESCRIPTION OF PIECE

WHEN WANTED

DATE | AMOUNT | DATE | AMOUNT

RETURN TO PLANNING DEPT. WHEN COMPLETED

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED

MONTH | DAY | YEAR

SIGNED BY FOREMAN

PRODUCTION ORDER NO.

MOVE

FROM

DEP'T

TO INSPECTION CAGE

PIECE NO | OPERATION NO

WE INSPECTED ABOVE W. | MACHINE NO | AND FIND AS FOLLOWS

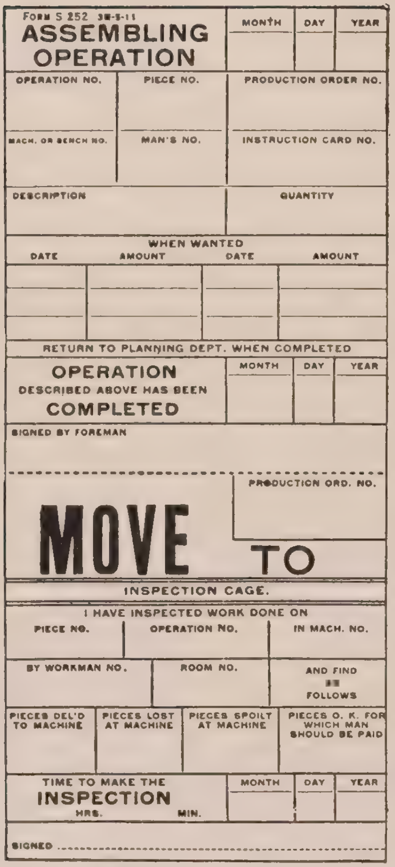
PIECES DELL TO MACHINE | PIECES LOST MACHINE | PIECES SPOILT AT MACHINE | PIECES O.K. FOR WHICH MAN SHOULD BE PAID

TIME TO MAKE THE INSPECT | HRS | MIN | RECEIVED

SIGNED

Fig. 61J—1 (old). Fig. 61J—2 (new).

Polishing Operation Order.



Form S 252 3M-5-11

ASSEMBLING OPERATION

MONTH | DAY | YEAR

OPERATION NO. | PIECE NO. | PRODUCTION ORDER NO.

MACH. OR BENCH NO. | MAN'S NO. | INSTRUCTION CARD NO.

DESCRIPTION | QUANTITY

WHEN WANTED

DATE | AMOUNT | DATE | AMOUNT

RETURN TO PLANNING DEPT. WHEN COMPLETED

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED

MONTH | DAY | YEAR

SIGNED BY FOREMAN

PRODUCTION ORD. NO.

MOVE TO

INSPECTION CAGE.

I HAVE INSPECTED WORK DONE ON

PIECE NO. | OPERATION NO. | IN MACH. NO.

BY WORKMAN NO. | ROOM NO. | AND FIND AS FOLLOWS

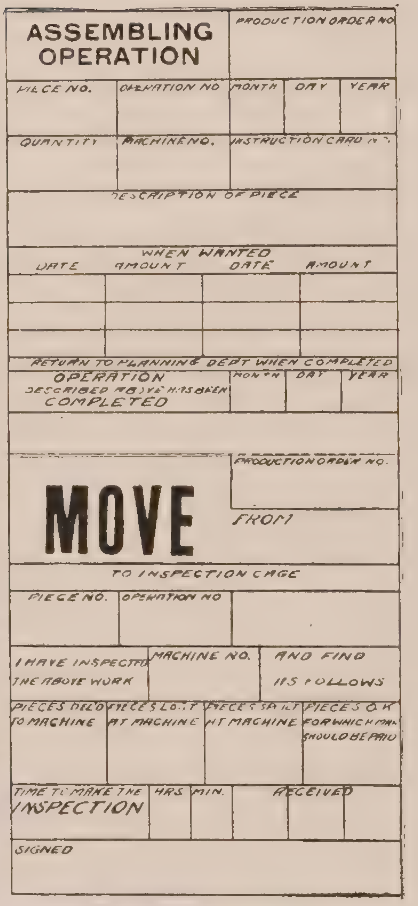
PIECES DEL'D TO MACHINE | PIECES LOST AT MACHINE | PIECES SPOILT AT MACHINE | PIECES O. K. FOR WHICH MAN SHOULD BE PAID

TIME TO MAKE THE INSPECTION HRS. MIN.

MONTH | DAY | YEAR

SIGNED ....

Fig. 61K—1 (old).



ASSEMBLING OPERATION

PRODUCTION ORDER NO

PIECE NO. | OPERATION NO | MONTH | DAY | YEAR

QUANTITY | MACHINE NO. | INSTRUCTION CARD NO.

DESCRIPTION OF PIECE

WHEN WANTED

DATE | AMOUNT | DATE | AMOUNT

RETURN TO PLANNING DEPT WHEN COMPLETED

OPERATION DESCRIBED ABOVE HAS BEEN COMPLETED

MONTH | DAY | YEAR

PRODUCTION ORDER NO.

MOVE FROM

TO INSPECTION CAGE

PIECE NO. | OPERATION NO

I HAVE INSPECTED THE ABOVE WORK | MACHINE NO. | AND FIND AS FOLLOWS

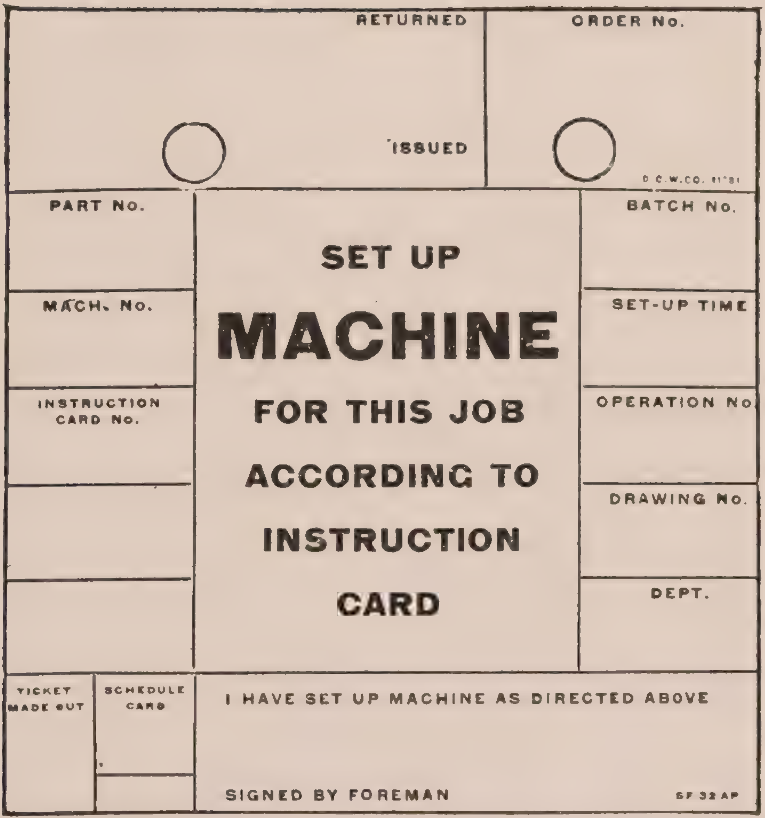
PIECES DEL'D TO MACHINE | PIECES LOST AT MACHINE | PIECES SPOILT AT MACHINE | PIECES O K FOR WHICH MAN SHOULD BE PAID

TIME TO MAKE THE INSPECTION | HRS | MIN. | RECEIVED

SIGNED

Fig. 61K—2 (new).

Assembling Operation Order.



RETURNED

ISSUED

ORDER No.

D.C.W.CO. 11'31

PART No.

MACH. No.

INSTRUCTION CARD No.

SET UP

MACHINE

FOR THIS JOB

ACCORDING TO

INSTRUCTION

CARD

BATCH No.

SET-UP TIME

OPERATION No.

DRAWING No.

DEPT.

TICKET MADE OUT

SCHEDULE CARD

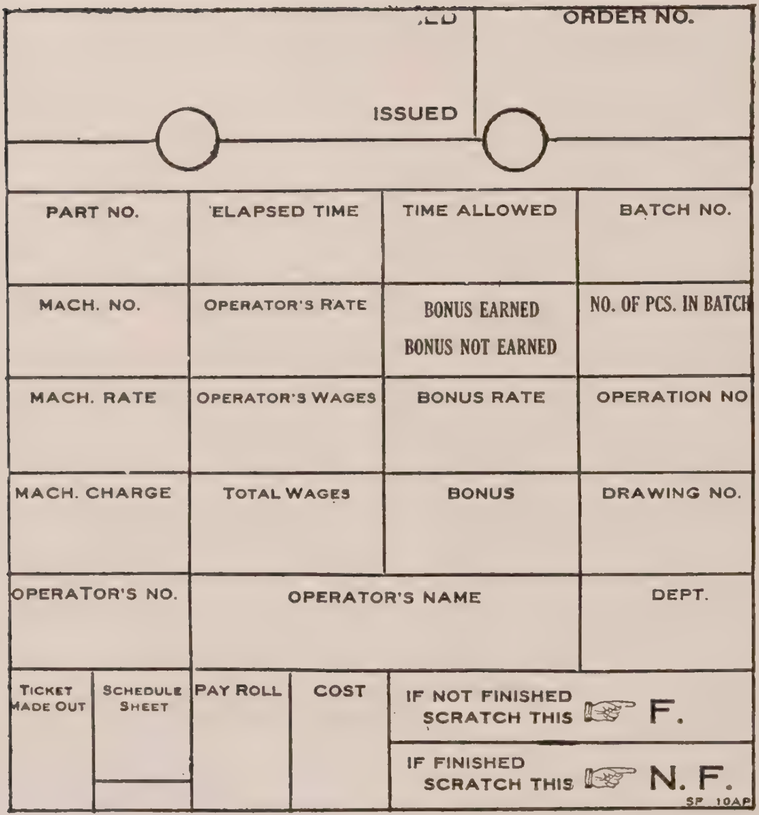
I HAVE SET UP MACHINE AS DIRECTED ABOVE

SIGNED BY FOREMAN

SF 32 AP

By Courtesy of the Square D Co.

Fig. 62A.—Machine Set-up Ticket.



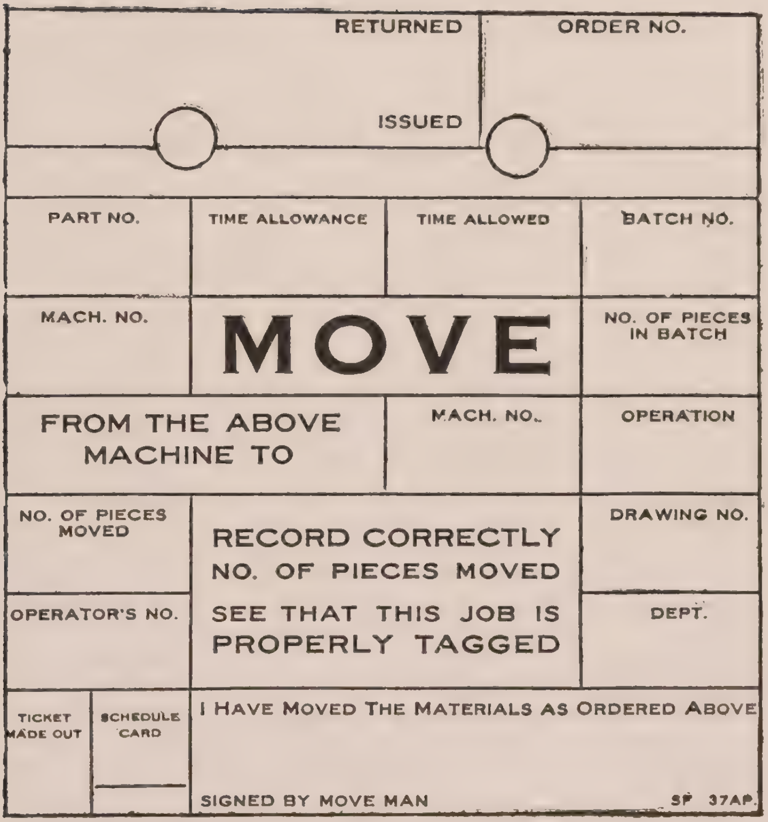
LD ISSUED		ORDER NO.	
PART NO.	ELAPSED TIME	TIME ALLOWED	BATCH NO.
MACH. NO.	OPERATOR'S RATE	BONUS EARNED BONUS NOT EARNED	NO. OF PCS. IN BATCH
MACH. RATE	OPERATOR'S WAGES	BONUS RATE	OPERATION NO
MACH. CHARGE	TOTAL WAGES	BONUS	DRAWING NO.
OPERATOR'S NO.	OPERATOR'S NAME		DEPT.

TICKET MADE OUT	SCHEDULE SHEET	PAY ROLL	COST	IF NOT FINISHED SCRATCH THIS ☞ F.
				IF FINISHED SCRATCH THIS ☞ N. F.

SP 10AP

By Courtesy of the Square D Co.

Fig. 62B.—Time Ticket.



RETURNED

ISSUED

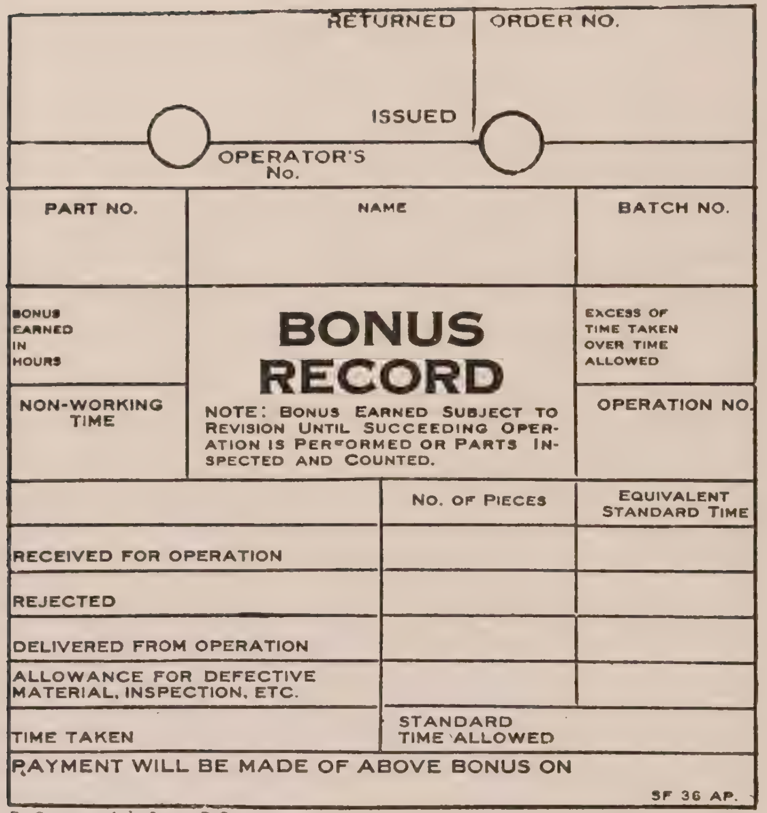
ORDER NO.

PART NO.	TIME ALLOWANCE	TIME ALLOWED	BATCH NO.
MACH. NO.	MOVE		NO. OF PIECES IN BATCH
FROM THE ABOVE MACHINE TO		MACH. NO.	OPERATION
NO. OF PIECES MOVED	RECORD CORRECTLY NO. OF PIECES MOVED		DRAWING NO.
OPERATOR'S NO.	SEE THAT THIS JOB IS PROPERLY TAGGED		DEPT.

TICKET MADE OUT	SCHEDULE CARD	I HAVE MOVED THE MATERIALS AS ORDERED ABOVE SIGNED BY MOVE MAN SP 37AP.

By Courtesy of the Square D Co.

Fig. 62C.—Move Order.



RETURNED

ISSUED

ORDER NO.

OPERATOR'S No.

PART NO.	NAME	BATCH NO.
BONUS EARNED IN HOURS	**BONUS RECORD**	EXCESS OF TIME TAKEN OVER TIME ALLOWED
NON-WORKING TIME	NOTE: BONUS EARNED SUBJECT TO REVISION UNTIL SUCCEEDING OPERATION IS PERFORMED OR PARTS INSPECTED AND COUNTED.	OPERATION NO.

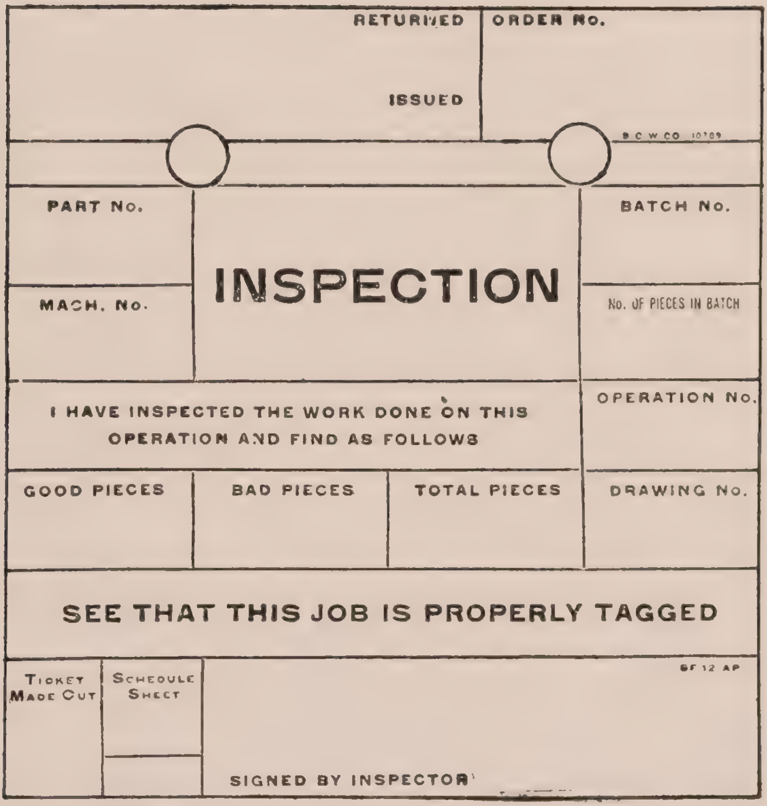
	NO. OF PIECES	EQUIVALENT STANDARD TIME
RECEIVED FOR OPERATION		
REJECTED		
DELIVERED FROM OPERATION		
ALLOWANCE FOR DEFECTIVE MATERIAL, INSPECTION, ETC.		
TIME TAKEN	STANDARD TIME ALLOWED	

PAYMENT WILL BE MADE OF ABOVE BONUS ON

SF 36 AP.

By Courtesy of the Square D Co.

Fig. 62D.—Bonus Record.



RETURNED

ISSUED

ORDER No.

S C W CO 10'89

PART No.

MACH. No.

INSPECTION

BATCH No.

No. OF PIECES IN BATCH

I HAVE INSPECTED THE WORK DONE ON THIS OPERATION AND FIND AS FOLLOWS

OPERATION No.

GOOD PIECES	BAD PIECES	TOTAL PIECES	DRAWING No.

SEE THAT THIS JOB IS PROPERLY TAGGED

TICKET MADE OUT

SCHEDULE SHEET

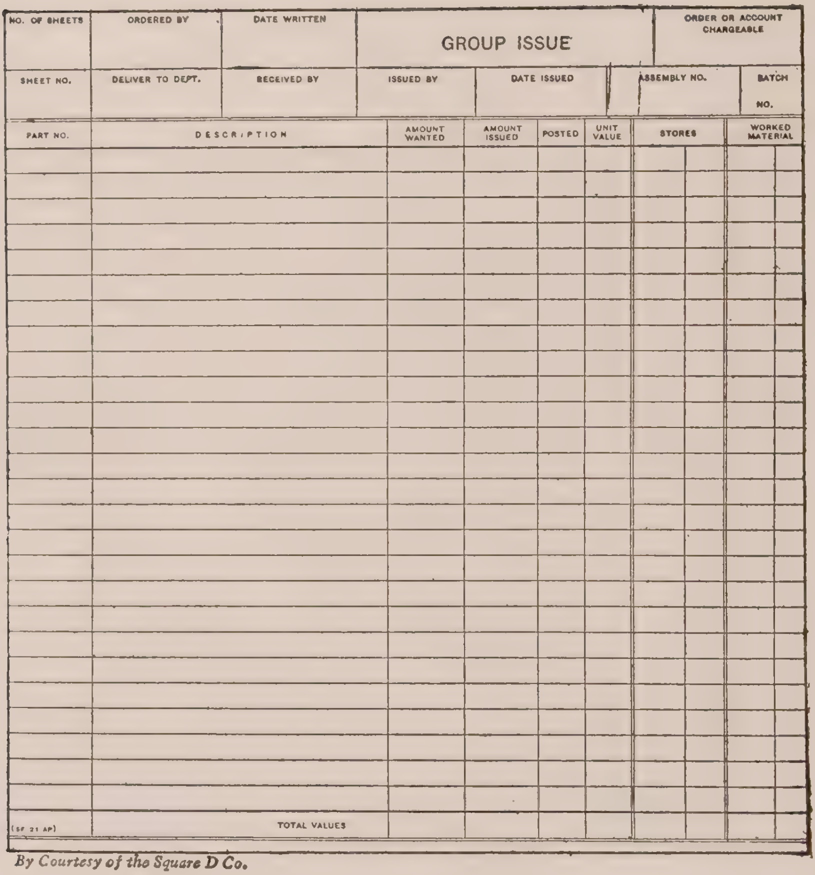
SF 12 AP

SIGNED BY INSPECTOR

By Courtesy of the Square D Co.

Fig. 62E.—Inspection.

where the values are calculated. Two columns are arranged for values in order to keep the values of the stores and worked material separate. Attention has also been given to the location of the spaces used for filing in the positions which accord with those of the other forms with which it is to be filed.



NO. OF SHEETS	ORDERED BY	DATE WRITTEN	GROUP ISSUE		ORDER OR ACCOUNT CHARGEABLE
SHEET NO.	DELIVER TO DEPT.	RECEIVED BY	ISSUED BY	DATE ISSUED	ASSEMBLY NO.	BATCH NO.

PART NO.	DESCRIPTION	AMOUNT WANTED	AMOUNT ISSUED	POSTED	UNIT VALUE	STORES		WORKED MATERIAL	
(SF 21 AP)	TOTAL VALUES								

By Courtesy of the Square D Co.

Fig. 63.—Group Issue.

Typewriter spacing between lines.—In laying out the details of forms it is essential to provide sufficient space for the data to be recorded. This means not only a sufficient number of square inches on the form, but also the proper distribution of the space to the items to be recorded. If the form is to be used on a typewriter no horizontal lines should be used to separate individual typewritten lines or else the spacing between them should be the same as the spacing on the typewriter to be used. Failure to attend properly to this detail means many hours of additional labor in filling out the form, for it becomes necessary to turn the platen by hand each time.

The ruling of forms.—In general there are two kinds of ruling employed in the preparation of printed forms: (1) the kind which is set up at the same time as the type and is printed with it, and (2) the kind which is made by means of ruling pens. The first kind is used whenever possible, as it is cheaper in most cases, for it is necessary to run the paper through the press but once to get a completed form. If the ruling pens are utilized, the type must be printed separately. If the ruling is to be done in two or more colors, as is often the case for ledgers, journals, etc., the second method is usually preferable, as several pens, each having different colored ink, can be used at one time, and so all the ruling in one direction can be done together. If the ruling were printed, it would be necessary to make as many impressions as there were colors to be ruled.

The typography of printed forms.—From the kind of ruling to the kind of type to be used is but a short step. It is essential, of course, that the type be clear and readable. This is especially true in the case of factory forms where many of the employees who must use them are not any too literate. There is no excuse for using ornate type which is difficult to read. For factory use there is hardly any kind of type more satisfactory than the Gothic in some one or more of its modifications. The forms shown in connection with this chapter are all printed in Gothic. The various modifications of this type permit almost any combination required and they go well together. While the prime object of a form is the service which it renders, there is no reason why it should not be made attractive to the eye when it costs no more, and especially, when it is also more usable.

Conclusion.—The principal details involved in the design of printed forms, while not important in themselves and not affecting any fundamental principle of administration, are important in that they cause losses through the unnecessary waste of time and errors which their proper design would have avoided. Their design is essentially a part of the setting of control standards, and, in so far as the factory is concerned, they are a part of the manufacturing standard. Like any other manufacturing standard their correct establishment (design) depends upon the possession by the person who performs this task of a thorough knowledge of their use, in addition to a certain amount of training in the technique of their preparation.

Reference for Additional Reading.

Clark, Wallace, "Shop and Office Forms: Their Design and Use."

CHAPTER XX

A MASTER SCHEDULE

Purposes of this chapter.—

1. To study the basis for the current control of operations of a manufacturing concern.
2. To see how that control depends on the interrelationships existing among the forecasts for the various functions.

The reason for setting manufacturing standards is to aid in the control of production. Essentially this control means planning the work to be done and then taking the necessary steps to see that it is done at the proper time. Equipment, workers, materials, standards, all are tools which the executive uses to produce desired merchandise.

Forecasting the future.—But in order to use these tools effectively the executive must forecast the future and arrange to employ them in such a way as to get the largest net returns from their use. All the details necessary for the daily performance of the various tasks should be planned and scheduled for definite times so that they may be coördinated. The entire production of the factory may be delayed through failure to arrange to have some part ready at a particular moment. Each detail must be dispatched at the time scheduled and be followed up until it is accomplished.

The interdependence of production and the other functions.—As soon as the attempt is made to do this for production, it is found that the probable future of other factors must be taken into consideration. Foremost of all is the question of sales, for it is obvious that it is useless to make goods unless they can be sold. The problem of financing the fabrication and sale of goods next demands attention, and before that can be solved the matter of materials, labor, operation expenses, etc., must all receive consideration. The control of production is not an isolated problem that can be solved by itself, for it is closely related to many other control problems, several of which are more or less coördinate with it, and on all of which it depends to a greater or less extent, and they in turn on it.

The master schedule.—Much attention has been given this matter of the proper forecasting of the future by business concerns as a basis for current operation under the term "budgeting," an expression carried over from government usage. The idea of evaluating the future for a long time in advance is an excellent one. The word "budget," however, hardly has exactly the right significance, for it implies to most persons a financial estimate of receipts and expenditures over a considerable period of time. Many parts of the business forecast are often in terms of physical units and the time periods involved are much shorter, especially for the immediate future. A good business program is more like a railroad time-table. Business operations, or certain portions of them, should reach particular points at predetermined times, and hence the term "master schedule" has been frequently adopted to describe that assembly of schedules which, in turn, controls each individual schedule and, in this way, controls the operation of the entire business. Such a master schedule must be laid out before the individual schedules for sales, production, finances, etc., can be definitely determined, though in the preparation of a master schedule ordinarily tentative subschedules must be developed.

The basic schedules of a manufacturing concern.—In a manufacturing concern the two basic elements of the master schedule are the sales and production schedules, or rather the sales' potentiality and production capacity. If these two factors can be balanced, a long step is taken in the direction of the formulation of a master schedule. If business is dull, the sales schedule will be the more important of the two, for the probability is great that the factory will be able to produce all that will be required of it. If, on the other hand, business is booming, then the productive capacity of the plant must be carefully evaluated and sales restricted to the quantities which the factory can manufacture. The essential importance of this balancing so far as possible of these two fundamental factors is all too frequently overlooked. It often results from the fact that the general manager has risen to his position from one or the other of these most important functions, and hence is induced to overestimate the importance of the function with which he is most familiar. This is, perhaps, quite natural; but it is a fault, nevertheless, and must be guarded against if the greatest possible success of the company is to be attained.

The productive capacity of a factory.—One of the first things which must be definitely ascertained is the productive capacity of the factory. In some cases this is a relatively simple task. It depends on the availability of manufacturing standards. If they have been accurately determined for the continuous process type of factory, then the rate of production is known and the factory capacity is determined for normal conditions. There is a certain amount of flexibility in the productive capacity of most factories of the continuous process type, for it is usually possible to work overtime and thus increase the output for a certain length of time, or even to add an extra shift, if the necessary employees are available. The continuous type of factory usually is the simplest kind from the production control point of view, because only one product goes through any one series of manufacturing operations.

In the intermittent and jobbing types of industry, on the other hand, even though carefully worked out standards are at hand, the evaluating of the factory capacity is not an easy task because of the many combinations of products which are possible. In fact, in most of these cases it is impossible to set any schedule for the shops in terms of quantity of product, either in units or value, and it is necessary to have recourse to a measurement of the plant capacity in terms of hours of work available at each class of production centers. This, in turn, complicates the preparation of the sales schedule to a certain extent, because it necessitates its calculation also in terms of hours. This measurement of the productive capacity and sales probabilities in terms of hours of available plant time is fundamentally correct for this type of business, for essentially the jobbing factory does not sell a product but services which may be employed in making that product. When this fact is appreciated, the reason for the propriety of using hours as a unit in which to prepare the schedules for this type of industry becomes apparent. In the jobbing type, as in the continuous type of industry, there is also a certain amount of flexibility due to the possibility of working overtime and adding extra shifts of workers.

The meaning of "productive capacity."—The productive capacity of a plant, when looked at as a whole, is something more than the capacity of the machinery which it possesses and the tools which it owns. It is dependent also on an available supply of labor and the ability to acquire the materials of all kinds which it may need in order to fabricate its product. The company may wish to operate two shifts, for example; but if it cannot get workers, the possibility of increasing the plant capacity in this way is distinctly limited. The same thing holds true in respect to materials. A plant may be obliged to work to less than its output simply because it cannot obtain raw materials. It is essential, therefore, to prepare schedules for labor and materials.

The sales schedule.—Before going on to a discussion of these schedules, it is desirable to consider briefly the sales schedule, since it is the other of the two basic schedules which enter into the make-up of the master schedule. The sales schedule must be based on records of past sales and on an estimate of future business conditions. From these two sources most of the information necessary to a valid forecast of future sales can be obtained. Of course, under these two main heads may be grouped an almost infinite number of details so that the above statement, sweeping as it is, is substantially correct. The records of the past, which should be used, include the sales divided according to months, kinds of product, and districts. With this, an analysis of returns should be included also. In addition to these internal records, it is essential to have records of what has taken place in the business world as a whole, analyzed according to types of product, localities, etc. With the aid of the various forecasts of business conditions which are prepared by research bureaus and are available to business men, and with the peculiarities of the cyclic changes which are identified with the particular concern in question, it is possible to foretell the probable amount of business which the company will have in the future, analyzed according to districts, product, etc., because ratios between the company's volume of business and certain barometers, like the rate of pig-iron production, for example, which are derived from the past experience, are likely to hold good in the future as they have in the past.

All this is intimately associated with the setting of salesmen's quotas, a subject familiar in general terms to all business men. In the continuous process type of industry such forecasts, combined with the measurement plant capacity, furnish a satisfactory means for obtaining the first tentative balance between sales potentiality and plant capacity, which is the backbone of the master schedule of a manufacturing plant. In the jobbing type of industry such a forecast of sales is harder to make, because of the necessity of measuring sales in terms of hours of work involved. Even though the forecast cannot be made with the same degree of accuracy which is possible for the continuous process type, it is not less, but rather more, valuable, for the jobbing type, because of the greater complexity of the control problems which must be faced.

The labor schedule.—It has already been stated that a labor schedule is a necessary part of the master schedule as a whole, and that it has a special bearing on the production schedule. This should be evident, for it is obvious that all of the means of production which are variable in their nature need to be planned for in advance. The basis for such a schedule is usually the shop equipment—the grade of employees and the number of new ones wanted, depending on the number of machines to be operated, or the immediate procurement of which is envisaged. Just as there are differences existing among machines, so there are among the workers. A lathe cannot do the work of a planer, neither can a semiskilled laborer replace an experienced mechanic. Hence, it is impossible to prepare a schedule in terms of number of workers without analyzing it according to the kinds of workers wanted.

This schedule must be predicated on the tentative balancing between the sales and production schedules, because only in this way can the probable number of workers be forecasted. If the forecast is made for a period when general business conditions are dull, it is highly probable that the tentative sales-production schedule will determine the labor schedule. If, on the other hand, the volume of business in general is large, it may well be that the labor forecast, as expressed in the labor schedule, may limit and curtail the general program.

The material schedule.—Much the same kind of thing is true in the case of materials that is true in regard to labor. The probable consumption of materials depends largely, if not wholly, on the future plans for production. If business is dull, all needed material is likely to be easily procurable; but if the boom time of the business comes during the course of the period for which the schedule is in preparation, there may be serious difficulties encountered in securing the materials desired. There is this difference between materials and labor, however, which simplifies the material schedule problem to a certain extent, at least. The concern which works out a master schedule and the component detailed schedules is the company which is looking farther into the future than most concerns. Hence, it is almost always possible for it to place contracts for the future delivery of materials which will enable it to obtain the goods wanted at the time when they are needed, except under exceptional circumstances. If the demand for goods is unusually heavy, it may be impossible to force the delivery of goods contracted for in advance at low prices when other concerns which did not forecast their needs are willing to pay a high premium for the immediate delivery of the same kind of materials. Of course, in the case of labor, it is impossible to contract for it in advance. The only way to secure labor is to hire it and that is a costly undertaking, unless there is work for labor to do at once. In both cases, however, a definite schedule carefully planned in advance is a great help to the realization of desired results.

Other detail schedules.—There are a number of other schedules which should enter into the composition of the master schedule, such as the advertising schedule, the tool schedule, the expense schedule, etc. Space is not available for their discussion, but there is one other schedule whose influence is so great on the master schedule and its constituent schedules that a few words must be devoted to it here. This is the financial schedule. In some ways it is the most important of all, for it is expressed in the only terms which provide a common measure for all of the schedules, namely, dollars and cents. In many cases, also, it is a controlling schedule, for if the other schedules cannot be financed it is impossible to carry them into effect.

The financial schedule.—There are two sides to the financial schedule—the expenditures and the income. The expenditures in a manufacturing concern depend largely, though not wholly, on factory activities. Some of the expenditures can be calculated directly from the schedules which have already been discussed. The value of the materials which go directly into the product can be computed once the material schedule has been tentatively outlined. The cost of labor can be forecasted from the labor schedule. Not only is it possible to evaluate the probable total expenditures for these items from the proper schedules, but, what is even more important, the time when those expenditures will probably be made can be forecasted.

In addition to these expenditures, there are also necessary disbursements for various kinds of expenses, the costs of the current operation of the business. These expenses include such items as the salaries of department heads; the wages of inspectors and storekeepers; the cost of supplies, such as oil, waste, stationery, etc.; and the cost of services rendered the concern which are represented by such charges as those for power, telephone and telegraph, the annual audit of the accounts, etc. All such details involve the disbursement of funds which must be provided when needed. The cost of advertising is still another item which represents an expenditure.

All these various charges serve to make up the expenditures side of the financial schedule. To meet them, income must be provided. Currently there are two main sources of income—sales and loans from banks. The loans from banks must be repaid, of course, from the income derived from sales; but temporarily bank loans are a way of securing funds which is very helpful in the preparation and putting into effect of a financial schedule. In the last analysis, however, the income from sales must be depended upon for the means of meeting current expenditures.

Just as the expenditure side of the financial schedule is derived largely from the production schedules and those most closely related to it, the income side of the financial schedule depends on data to be obtained from the sales schedule, for, in general terms, the payment of sales lags a certain length of time after the actual sale is made, the length of time depending on the nature of the business. Hence, frequently, the expenditures for materials must be made largely at the beginning of the period and the payments for labor currently during the period, while the income from sales may come only toward the end of the period or even after its close. If the company does not have the necessary cash or ability to borrow funds from the bank sufficient to bridge the gap between expenditures and income, as determined by the tentative schedules, these schedules must be modified, and so the master schedule in turn will be changed to meet the limitations of the financial schedule.

The preparation of the master schedule.—To prepare a master schedule, it is necessary first to work out the tentative detailed schedules which have been referred to several times in the preceding paragraphs. These schedules should be prepared by the heads of the several functions or departments whose work they immediately affect. The sales manager should be responsible for the tentative sales schedule; for example, the factory manager for the general production schedule, the production manager for the equipment, tool, and labor schedules, the purchasing agent for the materials schedule, the cost accountant for the expense schedule, the treasurer for the financial schedule, etc. These tentative schedules overlap to a certain extent, and, where they do, those in charge of them should consult concerning them so as to eliminate at the start as much of the disagreement which may exist among them as possible. These tentative schedules may be prepared for as long a time in advance as may seem desirable. The equipment schedule may forecast the needs of several years to come, while the labor schedule may not cover more than the next six months. All forecasts, however, which affect the master schedule which is in preparation should be prepared for the same period, usually six months or a year. The estimates for longer periods are made in more general terms than those for the shorter periods, and serve as the basis for the schedules for the shorter periods when the time for them approaches.

The general manager is the one who should take charge of the correlation of the tentative schedules and the preparation of the master schedule therefrom. He may relegate some of the less important details to an assistant, but he should keep the more important portions of the task in his own hands. The master schedule is one of the most valuable means of control over the entire business which the general manager has, and he should avail himself of its benefits to the fullest possible extent, something which is not possible if he relinquishes its entire preparation to another.

Obviously the tentative schedules will seldom agree in all their details, and it is necessary to reconcile their divergences. The best way to do this is by means of a conference at which the general manager presides, and all those who have had a part in the preparation of the tentative schedules are present. Such a procedure provides a ready means for answering any questions which may be raised, and for assuring all interested that the welfare of their particular function is not being overlooked. It should furnish one of the best ways of coördinating the efforts of all the departments and of developing an "*esprit de corps*" among the company executives.

When the master schedule has been finally prepared it should be reduced to graphic form, if that is possible, and the same should be done for the detailed schedules which are rounded out and made relatively permanent in the course of the preparation of the master schedule. It should be appreciated that such a schedule is a forecast, an estimate, and that it may be necessary to modify it as time shows that the forecast was incorrect in certain respects. It needs some flexibility, and to give it this desired possibility of alteration is often a difficult task. The fact that it is not perfectly realized does not detract from its value to the concern, for it performs its greatest service in causing a thorough evaluation of the future in the course of its preparation.

The master schedule, together with the manufacturing standards, is the basis for the planning, scheduling, and dispatching of current production. As such, it is one of the important elements in production control.

References for Additional Reading.

Lansburgh, R. H., "Industrial Management," Chapter XXXII.
Lichtner, W. O., "Time Study and Job Analysis," Chapter XXII.
Porosky, M., "Practical Factory Administration," Chapter XII.

Chapter XXI

PLANNING AND SCHEDULING PRODUCTION

Purposes of this chapter.—

1. To outline the problem of planning and scheduling production.
2. To study the relationship of planning and scheduling to manufacturing standards and a master schedule.
3. To survey the relationships of planning and scheduling to the detailed control of current production.

It is usually convenient to divide the current control of production into three parts, all closely related, but each independent of the other to a certain extent. These divisions are: (1) planning—the preparation in advance of the actual work of all of the necessary elements for the accomplishment of the task; (2) scheduling—the setting of dates and times for the performance of the several tasks planned; and (3) dispatching—the starting of the jobs according to the schedule and following them up to make sure that the work is done when and as directed.

Planning.—If the term "planning," as used in the preceding paragraph, is interpreted in its broadest sense, it would include many of the activities which have been discussed previously as a part of other functions. In general, however, the work of the Planning Department is not so extensive as this, for if it were, the setting of manufacturing standards, the maintenance of equipment, the procurement of tools, the purchase of materials, etc., would be a part of the task of this department. It is the function of the Planning Department, however, to request any information which it does not possess and to follow up these requests until they are granted. It is a part of the work of planning, for example, to check up the material required for an order, to order any which the records do not show to be available by writing a requisition on the

Purchasing Department, and to follow up the request until the Purchasing Department gives it proper attention.

Scheduling.—It will usually be found that the task of scheduling production is in practice, very closely interlocked with planning. It is a natural sequence to make plans for the future and to set definite times for putting them into effect. In the case cited above, it would be the normal thing for the Planning Department to set the date where the materials called for should be in the storeroom at the time that the request for the materials is sent out; and the same thing holds true for the other plans which are made.

Dispatching.—Dispatching is the third step which naturally follows the first two. In some cases, dispatching follows long after the plans and schedules are made. An order may be planned and scheduled for operation in the shops months in advance, and the actual dispatching of the work through the shop follows that much behind the planning and scheduling. On the other hand, the dispatching of the plans and schedules and its correlative—their follow-up—may frequently be practically coincident from the point of view of time. No sooner is the necessary material ascertained and the request for its purchase prepared than it is dispatched by the Planning Department to the Purchasing Department. It may rest in the latter department for some time before any further action is taken, but the control of production, in so far as it relates to the request for material by the Planning Department, has been dispatched.

The relationship of planning, scheduling, and dispatching.—It is evident, therefore, that planning, scheduling, and dispatching, as related to production, are closely related functions and that they are often performed in practice without any very distinct dividing line being set up among them. In a word, they represent an attempt to forecast the future operations of the factory and the guidance of present operations so that it will be possible to realize the forecasts. As carried on by the Planning Department, they should relieve the shops from all care for the future and allow the workmen and their foremen to concentrate on the accomplishment of the task which lies immediately under their hands as quickly and as well as possible.

The methods by which planning, scheduling, and dispatching production may be carried on are likely to vary according to the type of industry. In the continuous process type of industry where most of the work of control as well as of manufacture can be reduced to more or less of a routine, the problem of production control is greatly simplified and the procedure necessary is not complex, nor does it require the services of a large staff of clerks. In the jobbing type of industry where no manufacturing standards can be set nor any plans for an order made until the order for the goods is in hand, the adequate control of production is a far more complicated problem, often necessitating the detailed planning, scheduling, and dispatching of each step preliminary to the fabrication of the goods in the shop as well as for each operation needed for their manufacture.

The planning and scheduling of specifications.—Before the planning, scheduling, and dispatching of the work through the shop can be undertaken, a number of preliminaries must receive attention from the Planning Department and either be taken care of by it or assigned to other departments. In the first place, it is essential to make sure that the complete specifications for the goods and the materials of which they are composed are at hand. In some cases, the specifications of the product are included with the customer's order, but in other instances the Engineering or Designing Departments must prepare them. This is, of course, always true for the business which manufactures for stock. The Planning Department must gather together what information is available and send it to the department which is equipped to add to it any data which may be needed to aid in production or its control. In most cases this will be the Engineering Department, but in some instances it will be the Manufacturing Standards Department. In any event, it will be necessary to send the specifications through the latter department for checking and to enable it to get from them any data which it may need for other manufacturing standards. It is the duty of the Planning Deparment in this connection not only to send out what information it has and request any supplementary material which may be needed, but also to obtain promises as to the dates when the data will be completed, and then to follow up these promises to make sure that the specifications are ready on time, for on the basis of these promises the department must make other plans and schedules.

Of course, in continuous process and intermittent types of industry, the specifications of both product and material, when they are once prepared, are relatively lasting and should be at hand when it is necessary to plan for the future. They should be changed and improved from time to time, but the plans and schedules should not be based on new specifications until the latter are ready for use. This is a good illustration of the difference between the continuous process and jobbing type of industry in the production control problem.

The control of manufacturing standards.—In addition to the specifications of the product and materials it is also necessary to have various other manufacturing standards available as a basis for planning, scheduling, and dispatching. Equipment standards of one kind and another are among the most important of these. Another group which is essential is made up of the operation standards. In the continuous process type of industry these standards should be on hand as are the specifications, but in the jobbing type it is often necessary to prepare them for each order. In this latter type it is seldom possible to begin to prepare these other manufacturing standards until the specifications are available. Hence it is of major importance in the control of production to control the preparation of the specifications.

Routing orders through the factory.—One of the first of the manufacturing standards to need attention is the routing of the work through the shops. This, of course, necessitates the analysis of the manufacturing process for the article in question into a series of distinct operations, such as checking up the equipment to make sure that the necessary machines and implements are on hand and, if not, securing them. In most instances, of course, the machines will already be installed in the plant for manufacturing concerns do not normally accept orders which will require machinery other than that which they actually have on hand. There are cases, however, where some particular process will be required for which the company is not equipped and there are other instances where the machine on hand is not large enough to meet the needs of the customer's order. It is essential to know this early, so that provision may be made for taking care of such an operation either by buying the needed machinery, or, what is more likely, by arranging to have the work in question performed by some other concern. In both cases, it is necessary for the Planning Department to plan and schedule the work so that the machine will be installed and ready for operation by the time the operation for which it is needed is reached, or so that the outside concern does its work when and as scheduled.

A more frequent equipment problem of this same general nature is found in the case of tools, for it often happens that special tools are needed for a particular job while the machine on which they are to be used requires no modifications in order to be ready to receive them. All this means that the tools must be designed in the first place and either purchased from without or fabricated within the plant. The design of the tools, in most instances, will depend largely on the operation to be performed, and this, in turn, will depend on the routing of the work through the factory.

Planning and scheduling tool design and production.—If the Planning Department finds that new tools are necessary, it should notify the Manufacturing Standards Department, or the Tool Designing Department—if the company has a separate department for this purpose—to design the tools. As in the case of the specifications, the Planning Department should obtain specific promises as to the date when the design will be finished and should then follow up such promises to make sure that they are kept. If, for any reason, something prevents this, the Planning Department should be informed of this immediately so that it will be able to modify its plan and schedules accordingly.

In the continuous process type and the intermittent type of industry the tool problem resolves itself into a verification of the available supply of tools. This verification can be made by checking the records of the reserve supply of tools, a record which normally should be kept in the Planning Department.

It is equally important, once the design of the tools has been prepared, for the Planning Department to plan, schedule, and dispatch the production of the tools. In the small shop the Planning Department exercises its control in this matter much as it exercises it over the design of the tools by asking for promises from the foreman of the Tool Manufacturing Department and then by following up these promises. In the large factory, the Tool Manufacturing Department may assume the proportions of a direct Manufacturing Department and, under such circumstances, the Planning Department may control its work as it does those of the regular shops.

Operation standards.—The operation standards are still another manufacturing standard to be considered. Like the specification and the equipment, they will probably be at hand in the continuous process or intermittent types of industry, in the form of standard practice instructions and instruction cards. In the jobbing type of industry the problem is quite a different one, however, for it is necessary to set new standards for the order. In some cases at least, where some of the operations may be very like operations performed on other orders, it is possible to use those standards for the new order. In other cases, where unit time studies have been made, it is possible to use the results of these studies as a basis for setting the new operation standards for this order. In still other instances, it is impossible to do this, and the operation which is set will be only a rough approximation, but, nevertheless, it will be better than nothing. If the order is a large one and will run for a considerable period of time, it may be worth while to make some test runs and to make time studies on these runs. In one way or another, operation standards must be obtained, for it is important that the time needed for each operation should be a basis for planning and scheduling the work through the plant. It is a task of the Planning Department to ask for promises on dates for the preparation of these standards and then to follow them up.

All of the various manufacturing standards which are used in the course of production are necessary to the adequate planning and scheduling of work through the factory. In fact, it is necessary to have most of them at hand before any but the most general plans for production can be made. In the procurement of these standards, the Planning Department has an important task to perform by indicating in certain cases what standards are necessary, and in all instances its duty is to schedule and dispatch the requests for the standards and then follow them up so that they will be ready when they are needed for the detailed planning and scheduling of production.

Planning and scheduling manufacturing orders.—In addition to the preliminary data in the form of manufacturing standards which it is necessary for the Planning Department to have in order to plan and schedule production effectively, it is also essential that it have information in regard to the quantities of product which will be required and the dates when delivery must be made. Part of this information can be obtained from the master schedule in which the policies for the coming period are outlined in more or less general terms. In the case of the company manufacturing for stock, the master schedule should be followed until current events indicate that it is not an accurate forecast. The sales orders which the company receives are a means of checking up the schedule in this respect. If shipments are called for faster than the goods are being produced, it is necessary to increase the rate of production and to change production schedules accordingly. If sales are less than anticipated, the opposite must be done.

The relation of the master schedule to production scheduling.—In the jobbing type of industry, the scheduling of production is more dependent on the sales orders than in the type just described, as no work can be done until the order for it has been received. It is essential to fit the orders into the master schedule so that the Sales Department may be kept informed in regard to the extent of the plant capacity which is yet unscheduled and to aid it in making promises for delivery.

Four principal factors in scheduling production—(1) *Equipment.*—In planning and scheduling the work of the factory, there are four principal groups of factors which must receive consideration. One of these which must receive early consideration is the equipment. The particular factor has already been discussed in part in a preceding paragraph dealing with control of the design and production of tools. It must also receive consideration in that any special tools required for an order must not only be in existence but must not be in use for any other order at the time scheduled for the order in question. In the continuous process type of industry this is seldom a serious problem, but in the intermittent and jobbing types this matter must frequently be carefully scheduled.

More important than tools in this connection is the machinery on which the various operations are to be performed. In many instances, the machines are the limiting factor in production. Increasing amounts of material may be obtained, additional workers may be hired, and the orders, suborders, and instructions may be multiplied quickly. It is usually a relatively long process, however, to acquire new machinery, and hence the quantity of output for the immediate future is limited by that already installed, even though future plans may include extensive additions. It is essential, therefore, to schedule the work to the machines with a considerable degree of definiteness. The maximum limit is fixed by the available working hours. If the factory is working on a twenty-four-hour-day basis with three shifts of workers, this limit is definite. If it operates regularly fewer than twenty-four hours a day, the working hours may be extended by the use of overtime or by the hiring of an extra shift of workers, if labor conditions make it possible. The full number of working hours in a day should not be used as a basis for scheduling, however, for such an arrangement allows for no unforeseen contingencies which are sure to happen from time to time. Machines do break down occasionally in spite of the best care and frequent inspections to anticipate such occurrences. Production can be scheduled only on the basis of adequate maintenance of equipment, but adequate maintenance does not mean that breakdowns due to unforeseen causes may not occur. Moreover, there are numerous other reasons why the machines cannot be kept busy all of the working hours: materials may be delayed, the power or internal transportation system may break down, a key-worker may be sick and absent from work for several days, etc. As a result it is seldom wise to use more than eighty to ninety per cent, on the average, of the theoretically available working time as a basis for scheduling.

(2) *The scheduling of materials.*—Materials are another of the factors of production which must be scheduled with care. The basis for the scheduling of the materials is the master schedule and the sales order, as in the case of equipment. From the balance of stores and worked material cards and purchase and manufacturing orders, data in regard to the status of material may be obtained, and a schedule for material acquisition

may be set up from this information of quantities of material on hand, apportioned to orders and on order, and the scheduled dates of delivery of this ordered material. Such a schedule should show the dates when specified quantities of material are to be delivered, and should be set only after conference with the Purchasing Department and with the schedules of worked material, to make sure that the dates established are practical and can be lived up to. A special sheet may be prepared on which the record of this schedule and actual receipts may be made if the material is so important that the follow-up cannot be left to the regular routine of the Purchasing Department and the production schedule.

(3) *The control of the workers.*—The workers are a third factor which influences the control of production. To a consid-

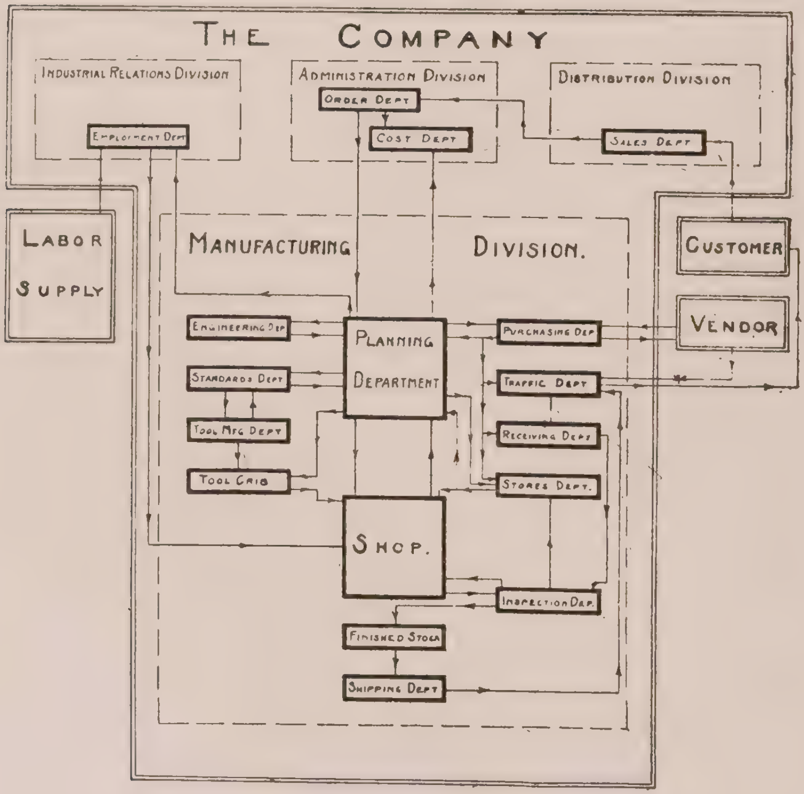


Fig. 64.—Diagram of Production Control.

erable extent, however, this factor does not present the same difficulties as equipment and materials present. This is due to the fact that workers are assigned to definite production centers and remain there so long as there is work to be done. Hence, in scheduling the work to the machines, it is also scheduled to the workers. In part, it is due to the flexibility of workers within certain limits, and to the possibility of shifting employees from one task to another. If there are certain key-workers who are subject to such shifts and without whom jobs cannot be accomplished, it is wise to schedule them in much the same way as equipment is scheduled.

(4) *Control of orders.*—Lastly, there are the orders and suborders which must be scheduled. If there are many orders, or if orders are subdivided into batches, there are often large numbers of time tickets, inspection slips, move orders, material issues, etc., to be prepared in advance. It is quite as much a task of the Planning Department to plan and schedule the preparation of these orders as it is any other element of production. Dates should be set for their preparation and these dates should be regularly followed up. The instruction cards are another form of the orders and their preparation is the last step in the setting of the operation standards. It is the duty of the Planning Department to see that these are secured from the Manufacturing Standards Department in time to be used in dispatching the orders through the factory.

Conclusion.—There are marked differences between the methods required for the planning and scheduling of production in a continuous process type of industry and those needed in a jobbing type of industry. In the first case, the layout of general schedules and the control of the daily issue of the principal materials and of certain key operations are sufficient in many cases for the entire control of production. In the jobbing type of industry, on the other hand, it is frequently necessary to plan, schedule, and dispatch every step in the production of goods from the time the customer's order is received until it is finally shipped. The methods must be developed to meet individual needs, but the fundamentals of planning and scheduling production which have been outlined in this chapter are of general applicability. In order to give a perspective of the production control activities, the following chart (Fig. 64) has been prepared.

References for Additional Reading.

Basset and Heywood, "Production Engineering and Cost Keeping," Chapters VII, IX.

Cartmell, M., "Stores and Material Control," Chapters XVII-XIX.

Porosky, M., "Practical Factory Administration," Chapters VI, XI.

Thompson, C. B., "Scientific Management," pages 366-394.

CHAPTER XXII

MATERIAL CONTROL

Purposes of this chapter.—

1. To outline the problem of material control.
2. To study some typical records used in this control.

From some points of view it may be said that the control of material is the control of production since, in controlling material from the time when it is known that raw material is wanted until the finished product is shipped, production will be controlled. It is perfectly justifiable to consider the physical units on which work is being done as material, no matter in what stage of fabrication it may be. For purposes of discussion here, a somewhat more limited definition of the term "material" is used, for by that expression only material before it enters into the final product is included.

Classification of materials from the control standpoint.— In many factories it is possible and desirable to divide material into two main classes or groups which are commonly called "stores" and "worked material." The term "stores" indicates all materials which are purchased from outside suppliers and are issued for use without being changed in form or condition from that which they possess when they are brought to the factory. By "worked material" is meant all material which is partially fabricated in the factory and then held in the Stores Department until needed to produce the final product. It is material which has been worked upon and which has reached a definite state of completion but is not yet salable merchandise except as repair parts. The reasons for this division are two: (1) the methods of acquisition of these two groups of material are radically different—one is by purchase and the other is by manufacture; and (2) because of this difference in the way the material is obtained; the manner of ascertaining the cost of the two different kinds of material is also different. As a matter of convenience, therefore, this distinction between them is made. As the worked material is made in the factory its production is controlled in substantially the same way as that of the merchandise.

Factors in material control.—Whether the material is stores or worked material, the problems which it involves may be divided into a number of subheads:

1. Determination of what material is wanted.
2. Determination of *how much* is wanted and *when.*
3. Procuring it by purchase or manufacture.
4. Receiving, storing, and issuing it when needed.
5. Development of a system to promote the efficient accomplishment of these functions.

The first of these topics has already been discussed under the head of material specifications. The second is a part of the work of the Planning Department and a general outline of what is involved has been presented in the preceding chapter. It is discussed at greater length in subsequent paragraphs.

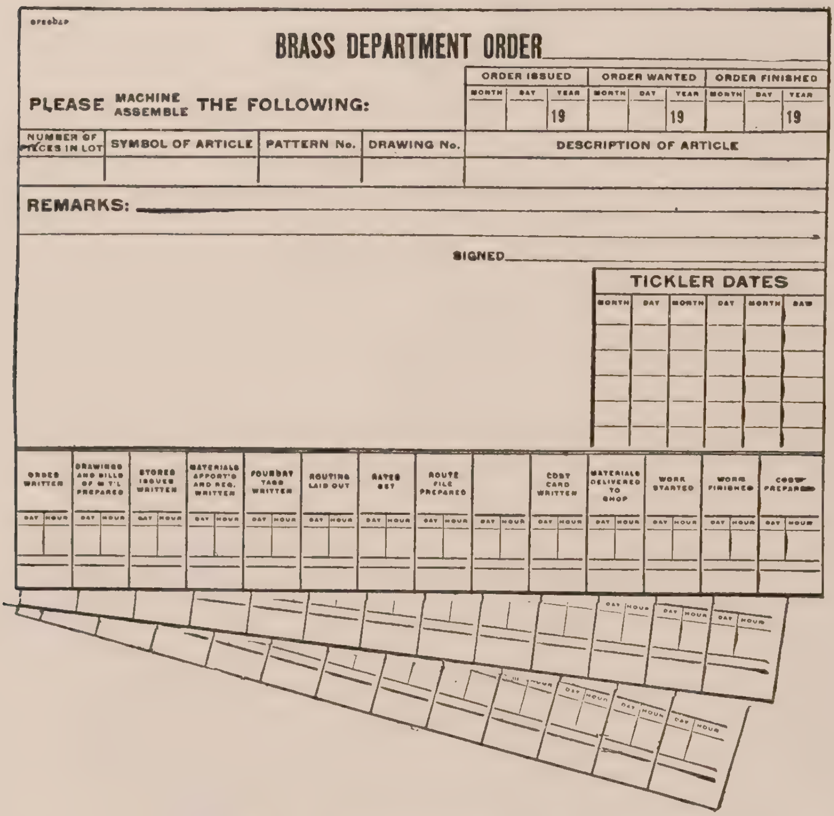
The third of these topics, in so far as the purchase of materials is concerned, is discussed in the following chapter, and the fourth in the chapter after that. The development of standard methods of procedure for the control of material is one of the tasks of the Manufacturing Standards Department, but it can be better discussed here than in the chapters devoted to manufacturing standards.

The scheduling of materials.—A purchasing schedule is one of the important components of a master schedule. It will be found in practice that it is impossible to schedule all materials in advance except in general terms, and that there is really no need of endeavoring to do so. It will usually be found that there are a few key materials which must be forecasted with considerable care for some time in advance, but that many others need attention only shortly before they are required for the factory. There are two important reasons for this condition which appears to be contrary to the idea that all details should receive consideration beforehand. In the first place, it is often found that many parts are made from the same kind of material. A machine shop, for example, can produce a large variety of parts from half-inch round machinery steel. Hence the purchase schedule may contain only one item for perhaps several hundred parts. In many cases, also, it is possible to place orders in advance for material on which the specifications are left open within certain limits. The company doing the purchasing agrees to complete the specifications a certain length of time before it calls for delivery and also to take certain quantities of materials within agreed dates. Insulated copper wire, for example, is made on machines which are capable of producing wire of a number of sizes, 16 to 22 B & S gauge, for example. The purchasing company agrees to take so many pounds of wire within these gauges over a particular period. In preparing its purchasing schedule, therefore, the company can deal with groups of sizes of wire and does not need to specify the exact sizes till later. The selling company, moreover, obtains sufficient information when a contract is placed with it in this form so that it can forecast its own needs fairly definitely.

The second reason why a purchasing schedule can be worked out in general terms is that many small items are produced on a quantity basis and hence can be procured on the open market or on order with very little delay at practically the same cost as though they were scheduled for a long time in advance. This is true except when the market is hardening rapidly. In most cases, also, these small articles cost little in proportion to the entire cost of the product and hence fluctuations in their price are relatively unimportant. It is quite true, however, that no item is so small that it is wise to neglect it, and in the discussion which follows of a typical method it will be seen that the rejected materials are not overlooked.

The starting point for the current and detailed control of material is the manufacturing order (see Figure 65). As soon as such an order is written, it immediately calls for the specification of the article to be produced. Such a specification is usually given in the form of a bill of material, if more than one kind of material or a number of different parts are required. The bill of material is usually prepared by the Engineering Department as has already been pointed out. The Planning Department calls for this bill of material and follows up its request until it is granted.

Material list.—It frequently occurs that it is desirable to prepare a material list (see Figure 66). This material list is ordinarily prepared by the Manufacturing Standards Department at the request of the Planning Department. Its purpose is to gather together information concerning the material required for the order in such a way that it may be most easily



BRASS DEPARTMENT ORDER__________

PLEASE MACHINE / ASSEMBLE THE FOLLOWING:

ORDER ISSUED			ORDER WANTED			ORDER FINISHED		
MONTH	DAY	YEAR	MONTH	DAY	YEAR	MONTH	DAY	YEAR
		19			19			19

NUMBER OF PIECES IN LOT	SYMBOL OF ARTICLE	PATTERN No.	DRAWING No.	DESCRIPTION OF ARTICLE

REMARKS: __________

SIGNED__________

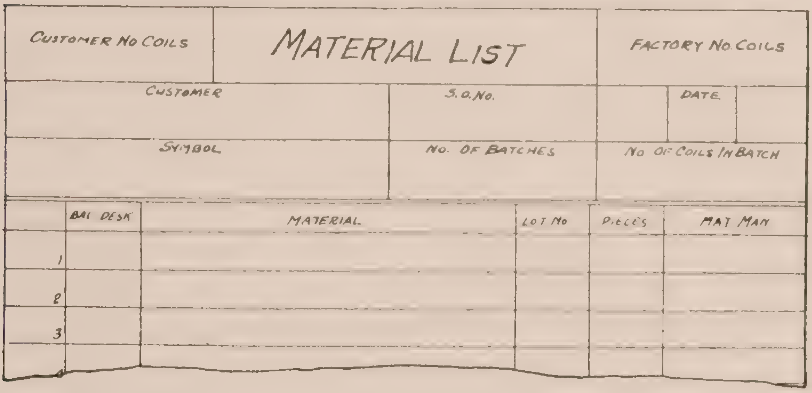
TICKLER DATES					
MONTH	DAY	MONTH	DAY	MONTH	DAY

ORDER WRITTEN	DRAWINGS AND BILLS OF M'T'L PREPARED	STORES ISSUES WRITTEN	MATERIALS APPORT'G AND REQ. WRITTEN	FOUNDRY TAGS WRITTEN	ROUTING LAID OUT	RATES SET	ROUTE FILE PREPARED		COST CARD WRITTEN	MATERIALS DELIVERED TO SHOP	WORK STARTED	WORK FINISHED	COST PREPARED
DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR	DAY HOUR

Fig. 65.—Manufacturing Order.

used by the Planning Department for planning and scheduling. It does this by embodying two changes from the bill of material: (1) it eliminates all materials which are not specifically required for the particular order, and (2) it shows the exact quantity of each kind of material required for the order.

At first glance it may appear unwise to eliminate any item from a list of material required for a particular order. It not infrequently occurs, however, that a bill of material shows glue, shellac, enamel, and other material of this sort which cannot be measured conveniently against any particular order. A furniture factory, for example, uses glue to attach certain parts of the furniture together. At the production center where parts are glued, a glue pot is kept filled with hot glue and each order as it comes to a gluing operation receives as much glue as it needs. It is quite unnecessary to order glue specifically for any particular order, and hence it is not put on the material list. This same condition is found in the case of the other materials mentioned and in many other instances as well. Small screws, nuts, washers, powder for filling electrical fuses, etc., all fall in this class of material. Such items are treated in the same way as supplies—oil, waste, etc.—and are ordered when needed, as explained in a later paragraph.



CUSTOMER NO COILS	MATERIAL LIST		FACTORY NO. COILS
CUSTOMER	S. O. NO.	DATE	
SYMBOL	NO. OF BATCHES	NO OF COILS IN BATCH	

	BAL DESK	MATERIAL	LOT NO	PIECES	MAT MAN
1					
2					
3					

By Courtesy of the Acme Wire Co.

Fig. 66.—Material List.

It often happens, also, that more than one unit of a particular part is used on a unit of the finished product. There are several pistons and connecting rods for each engine assembly of an automobile—for example, two buckles on a brief case, four wheels on a farm wagon, etc. In addition, it is sometimes necessary to order more of some parts than of others because of the heavier spoilage during the course of manufacture. Experience and study will determine how large these allowances should be. It is essential that sufficient material of all kinds be obtained for the order. If it is necessary to multiply the number of units in the order by the number of parts per unit and then, perhaps, add an allowance to take care of spoilage at the time when the material is being checked and ordered, there is considerable chance for errors being made. The material list provides a convenient means of dealing with this problem.

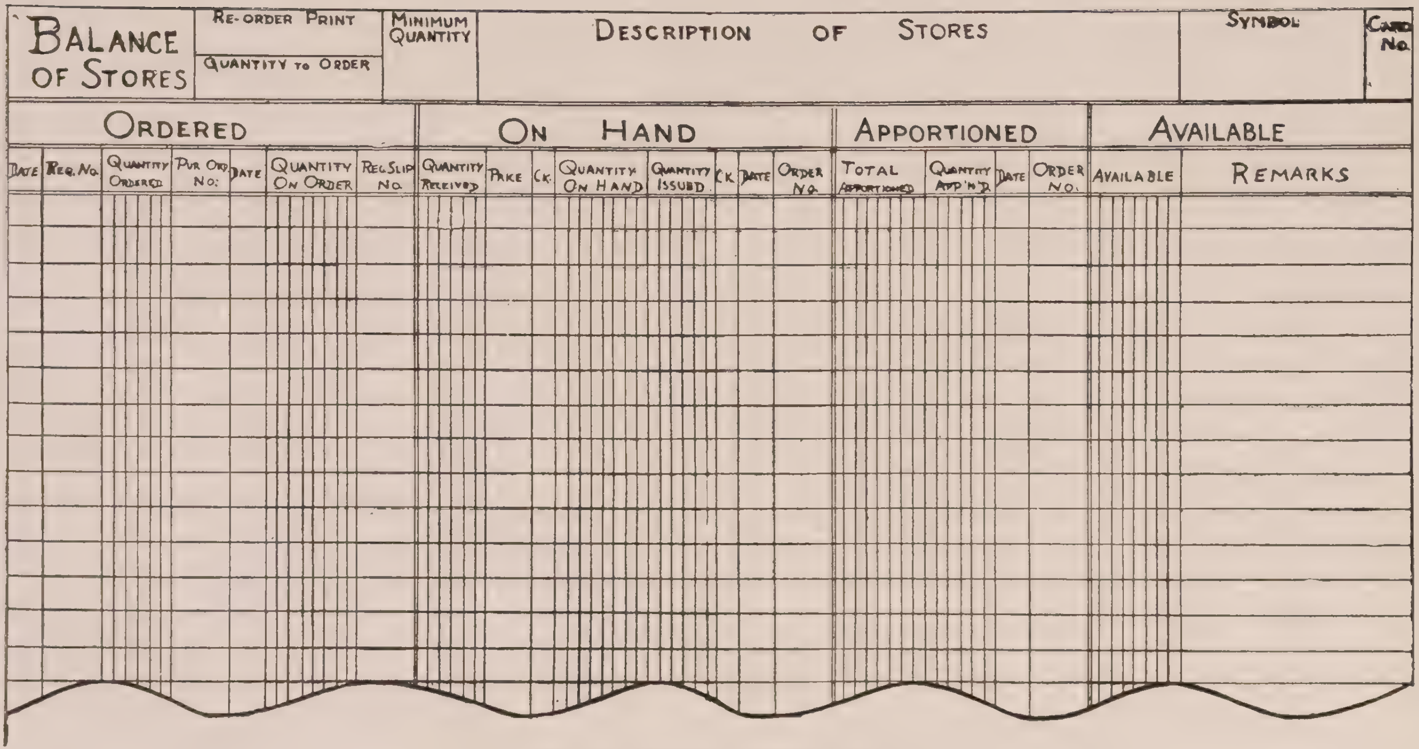
With the bill of material, the manufacturing order and a list of percentage allowances, prepared by the Manufacturing Standards Department showing the percentage to be added on certain classes of parts at hand, the proper quantity of each kind of material can readily be calculated and recorded on the material list, which then serves as a convenient means of checking and ordering the material required for the manufacturing order in question.

The ordering of material.—After the material list has been prepared, it is necessary to order the needed material. Before this can be done, however, it is important to find out whether it is actually necessary to order any, for it is possible in certain cases that material enough may be available. This leads at once to the records which tell the condition of the material under consideration. The most advanced type of such a record is called a "balance of stores" (or "balance of work material") record which adds to a perpetual inventory of the material information concerning the quantities of material on order, apportioned or assigned orders already scheduled but which have not yet been issued for their use, and any remaining material which is available for the benefit of the order in question or any shortage which may have been allowed to accumulate for any reason (see Figure 67).

The material required for any order which is being scheduled should be apportioned and, if enough of it is not available, more should be ordered at once by writing a purchase requisition in the case of stores and a manufacturing order if the item is worked material.

Maximum and minimum quantities.—When the material is of a sort which is not ordered specifically for a particular order, another procedure is ordinarily desirable. This kind of material includes not only such items as were described as ones to be left off of the material list, but also supplies of various sorts. The basis for the ordering of such material depends on what is known as "maximum and minimum quantities." This term does not describe the method very well, however, and, as it is important, it is desirable to explain it in detail here.

As the result of past experience with the rate of consumption of each item of this kind of material and of a forecast as to the probable future rate of use combined with a forecast of the probable length of time required to get the material, a



BALANCE OF STORES	RE-ORDER PRINT QUANTITY TO ORDER	MINIMUM QUANTITY	DESCRIPTION OF STORES	SYMBOL	CARD No.

ORDERED							ON HAND								APPORTIONED				AVAILABLE	
DATE	REQ. NO.	QUANTITY ORDERED	PUR. ORD. NO.	DATE	QUANTITY ON ORDER	REC. SLIP NO.	QUANTITY RECEIVED	PRICE	CK.	QUANTITY ON HAND	QUANTITY ISSUED	CK.	DATE	ORDER NO.	TOTAL APPORTIONED	QUANTITY APP'N'D	DATE	ORDER NO.	AVAILABLE	REMARKS

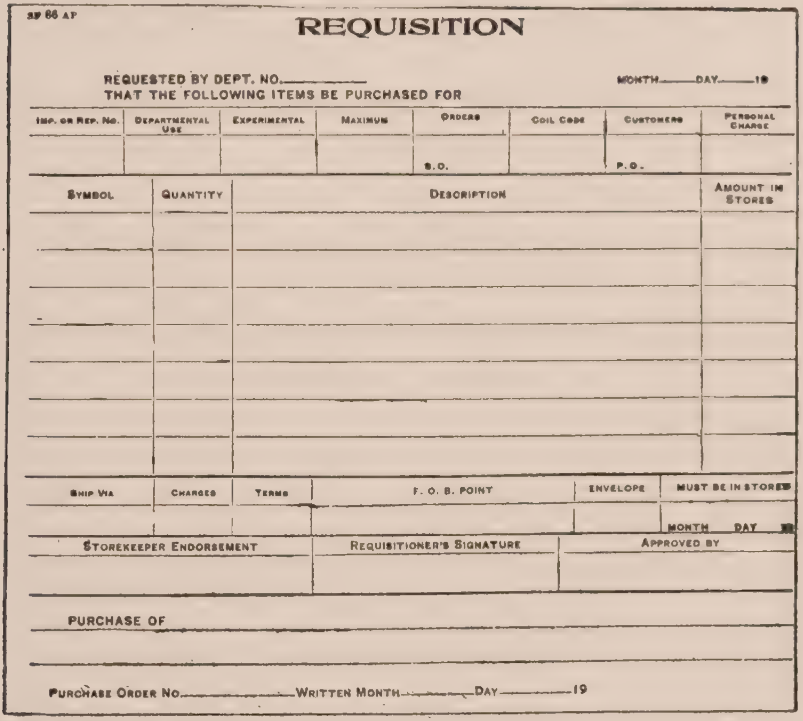
Fig. 67.—Balance of Stores Card.

definite quantity is determined. When the material on hand falls to that point, an order is placed for more material, the quantity ordered depending on the rate of consumption, the economical quantity to purchase, the length of time which it takes to get the material actually into the storeroom after it is requisitioned, and any special factors which may affect particular kinds of material.

In this way the two points usually called the minimum and maximum points are fixed, the maximum being the minimum plus the standard quantity to order. There is one trouble with this plan as it stands, however. Either the minimum quantity is placed so high that there is no chance of the supply of material being exhausted before more is received, or else it is put too low and there is constantly a lack of material of one kind or another. In the first instance, the inventories carried are much larger than necessary, with an unnecessary expenditure as a result. In the second case, the work of the factory is hampered and schedules are frequently deranged due to lack of material.

The reason for this lies in the fact that the minimum quantity is being used for two purposes which are complementary in so far as the control of material is concerned, but not the same. What is needed is two points—one a re-order point and the other a danger point. When the quantity of material on hand and on order falls to the re-order point, another quantity whose amount is determined, as has been previously described, should be ordered. In the normal course of events, material will be received before the quantity on hand falls to the danger point or is entirely exhausted. As soon as the quantity actually on hand falls to the danger point, immediate action is necessary. The purchasing agent should be informed by telephone of the facts and the telephoned information should be confirmed in writing. He should, in turn, use the telephone and telegraph to follow up the purchase order for the material, and employ express or motor truck to get it in. He should personally supervise such items, unless he has some assistant who is especially well qualified to relieve him of this task. The matter is an emergency and should be treated as such.

The purchase requisition.—When it has been determined that more material is necessary it should be ordered by writing a purchase requisition (see Figure 68) requesting the purchasing agent to buy it. If the material is to be used for a particular order the date or dates when delivery at the plant is necessary should be specified thereon. Unless this information can be conveniently recorded on the material list, all purchase requisitions for material of this kind should be sent to the schedule clerk to have such dates added after the requisition has been written by the balance clerk. The purchasing agent is then held responsible for getting the material to the factory as specified unless he immediately reports that it is impossible to do so. An adjustment must then be made at a conference between him and the production manager and schedule clerk.



39 66 AP

REQUISITION

REQUESTED BY DEPT. NO.________ MONTH_____DAY_____19

THAT THE FOLLOWING ITEMS BE PURCHASED FOR

IMP. OR REP. NO.	DEPARTMENTAL USE	EXPERIMENTAL	MAXIMUM	ORDERS	COIL CODE	CUSTOMERS	PERSONAL CHARGE
				S.O.		P.O.	

SYMBOL	QUANTITY	DESCRIPTION	AMOUNT IN STORES

SHIP VIA	CHARGES	TERMS	F. O. B. POINT	ENVELOPE	MUST BE IN STORES
					MONTH DAY 19

STOREKEEPER ENDORSEMENT	REQUISITIONER'S SIGNATURE	APPROVED BY

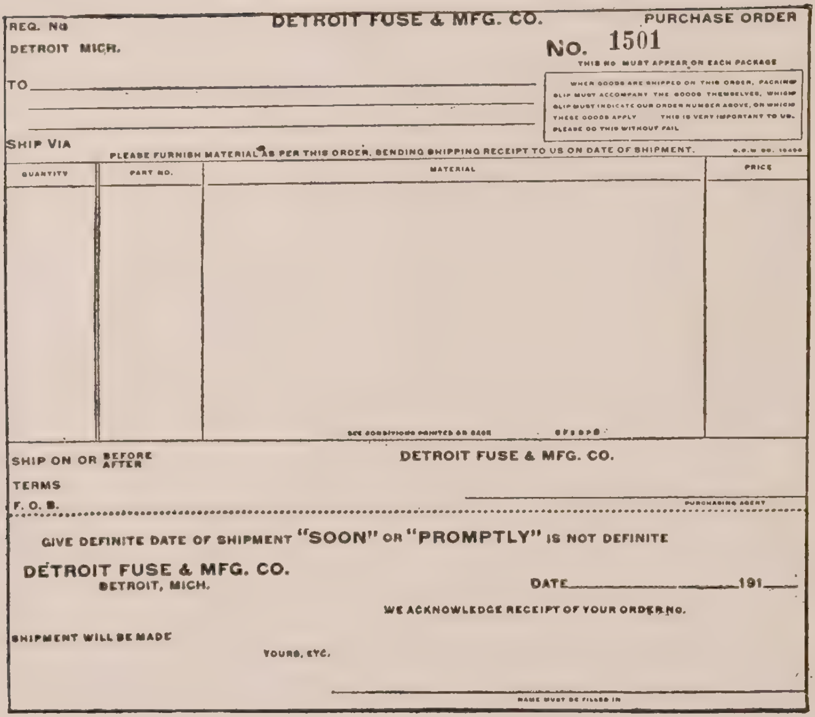
PURCHASE OF

PURCHASE ORDER NO.________WRITTEN MONTH______DAY______19

By Courtesy of the Acme Wire Co.

Fig. 68.—Purchase Requisition.

Purchase control forms.—A purchase order (see Figure 69) is used as the instrument for buying material. The first copy, when accepted by the vendor, becomes a legal contract. Other copies are used in the Purchasing Department



REQ. NO
DETROIT FUSE & MFG. CO.
PURCHASE ORDER
DETROIT MICH.
No. 1501
THIS NO MUST APPEAR ON EACH PACKAGE

TO ____________________

WHEN GOODS ARE SHIPPED ON THIS ORDER, PACKING SLIP MUST ACCOMPANY THE GOODS THEMSELVES, WHICH SLIP MUST INDICATE OUR ORDER NUMBER ABOVE, ON WHICH THESE GOODS APPLY THIS IS VERY IMPORTANT TO US. PLEASE DO THIS WITHOUT FAIL

SHIP VIA
PLEASE FURNISH MATERIAL AS PER THIS ORDER, SENDING SHIPPING RECEIPT TO US ON DATE OF SHIPMENT.

QUANTITY	PART NO.	MATERIAL	PRICE

SEE CONDITIONS PRINTED ON BACK OVER

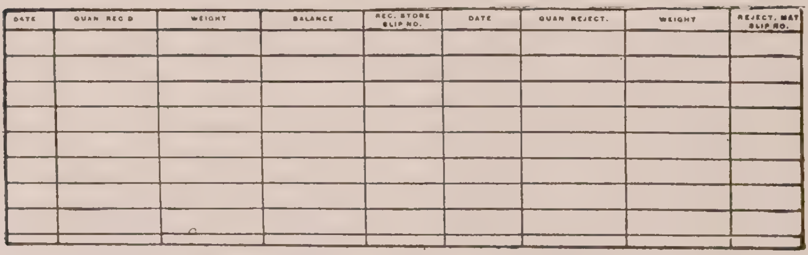
SHIP ON OR BEFORE / AFTER
DETROIT FUSE & MFG. CO.
TERMS
F. O. B.
PURCHASING AGENT

GIVE DEFINITE DATE OF SHIPMENT "SOON" OR "PROMPTLY" IS NOT DEFINITE

DETROIT FUSE & MFG. CO.
DETROIT, MICH.
DATE ____________ 191__
WE ACKNOWLEDGE RECEIPT OF YOUR ORDER NO.
SHIPMENT WILL BE MADE
YOURS, ETC.
NAME MUST BE FILLED IN

By Courtesy of the Detroit Fuse & Mfg. Co.

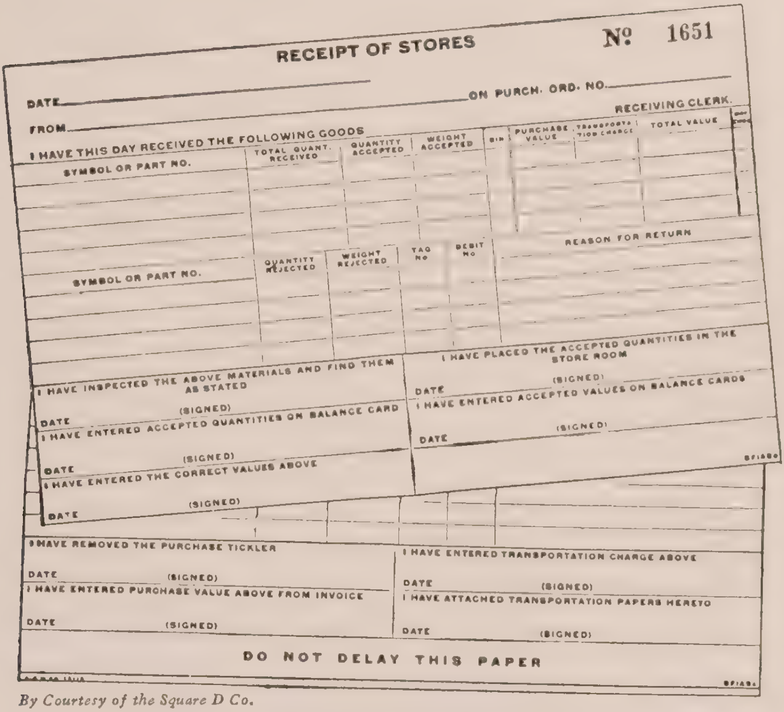
Fig. 69A.—Purchase Order—Obverse.



DATE	QUAN REC'D	WEIGHT	BALANCE	REC. STORE SLIP NO.	DATE	QUAN REJECT.	WEIGHT	REJECT. MAT SLIP NO.

Fig. 69B.—Purchase Order—Reverse.

and Receiving Department as a means of recording the status of the order. When material is received in the Receiving Department, a record of it is made on a receiving slip (see Figure 70) which is used to convey the necessary information to the Purchasing, Stores, and Planning Departments. If material is rejected for any reason, its value is debited to the vendor and, if the latter so desires, is shipped back to him. A return of rejected materials form (see Figure 71) is used for this purpose.



RECEIPT OF STORES

№ 1651

DATE ON PURCH. ORD. NO.

FROM RECEIVING CLERK.

I HAVE THIS DAY RECEIVED THE FOLLOWING GOODS

SYMBOL OR PART NO.	TOTAL QUANT. RECEIVED	QUANTITY ACCEPTED	WEIGHT ACCEPTED	BIN	PURCHASE VALUE	TRANSPORTATION CHARGE	TOTAL VALUE

SYMBOL OR PART NO.	QUANTITY REJECTED	WEIGHT REJECTED	TAG NO	DEBIT NO	REASON FOR RETURN

I HAVE INSPECTED THE ABOVE MATERIALS AND FIND THEM AS STATED
DATE (SIGNED)

I HAVE ENTERED ACCEPTED QUANTITIES ON BALANCE CARD
DATE (SIGNED)

I HAVE ENTERED THE CORRECT VALUES ABOVE
DATE (SIGNED)

I HAVE PLACED THE ACCEPTED QUANTITIES IN THE STORE ROOM
DATE (SIGNED)

I HAVE ENTERED ACCEPTED VALUES ON BALANCE CARDS
DATE (SIGNED)

I HAVE REMOVED THE PURCHASE TICKLER
DATE (SIGNED)

I HAVE ENTERED PURCHASE VALUE ABOVE FROM INVOICE
DATE (SIGNED)

I HAVE ENTERED TRANSPORTATION CHARGE ABOVE
DATE (SIGNED)

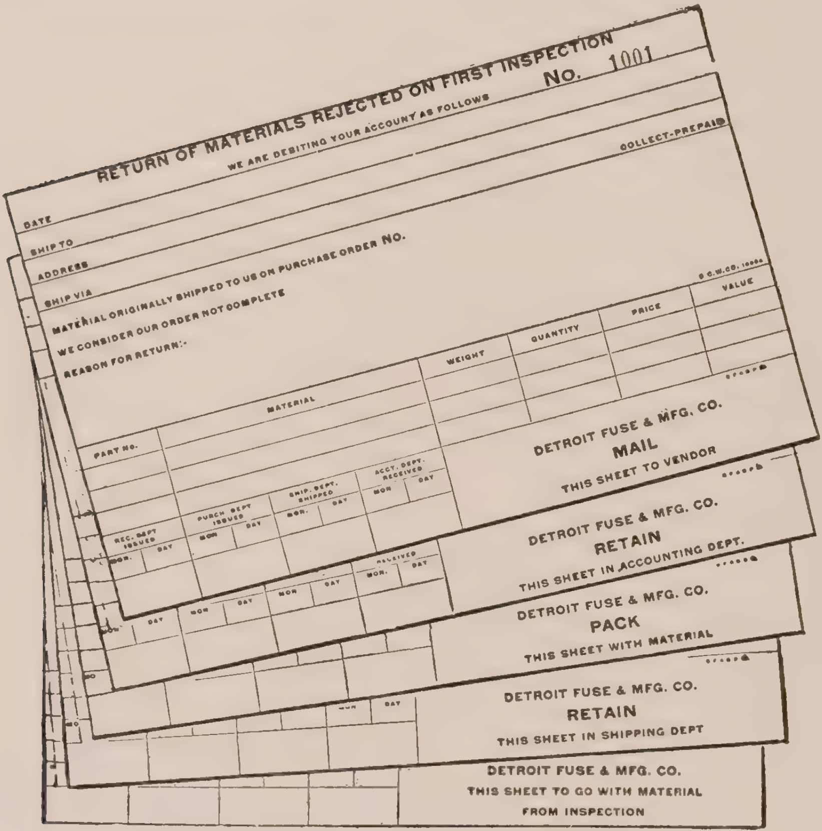
I HAVE ATTACHED TRANSPORTATION PAPERS HERETO
DATE (SIGNED)

DO NOT DELAY THIS PAPER

By Courtesy of the Square D Co.

Fig. 70.—Receiving Slip.

Internal material control forms.—When material is wanted for use in the factory a material issue of some kind is employed to direct its delivery to the shop. If a single kind of item is wanted at one time, a stores or worked material issue is the form used for this purpose. If several different kinds are wanted for the use of a single order, a group issue (see Figure 63) is utilized. When a certain portion of the material which has been issued is returned unused to the storeroom for any reason, a record of it is made on a credit slip (see Figures 60 B and D). When worked material is completed and turned in to the Stores Department to be held till it is needed for other orders, a worked material in-slip (see Figure 60 E) is used. All of these forms contain information which is entered regularly on the appropriate balance card, which is the controlling record in so far as material is concerned. It should also be noted that these same forms enter into the cost records, so their utility does not cease with the service which they render in the immediate control of production. These forms not only serve as a means of indicating the transfer of quantities and values, but they are also employed as a part of the mechanism used for dispatching work through the factory. Altogether they represent an important part of the system of production control.



RETURN OF MATERIALS REJECTED ON FIRST INSPECTION

No. 1001

WE ARE DEBITING YOUR ACCOUNT AS FOLLOWS

DATE

SHIP TO

ADDRESS

SHIP VIA COLLECT-PREPAID

MATERIAL ORIGINALLY SHIPPED TO US ON PURCHASE ORDER NO.

WE CONSIDER OUR ORDER NOT COMPLETE

REASON FOR RETURN:-

PART NO.	MATERIAL	WEIGHT	QUANTITY	PRICE	VALUE

REC. DEPT. ISSUED MON. DAY

PURCH. DEPT. ISSUED MON. DAY

SHIP. DEPT. SHIPPED MON. DAY

ACCT. DEPT. RECEIVED MON DAY

DETROIT FUSE & MFG. CO.
MAIL
THIS SHEET TO VENDOR

DETROIT FUSE & MFG. CO.
RETAIN
THIS SHEET IN ACCOUNTING DEPT.

DETROIT FUSE & MFG. CO.
PACK
THIS SHEET WITH MATERIAL

DETROIT FUSE & MFG. CO.
RETAIN
THIS SHEET IN SHIPPING DEPT

DETROIT FUSE & MFG. CO.
THIS SHEET TO GO WITH MATERIAL
FROM INSPECTION

By Courtesy of the Detroit Fuse & Mfg. Co.

Fig. 71.—Return of Rejected Materials Slip.

Material control in the continuous process type of industry.—Such a system is typical of the kind found in the well-organized jobbing or intermittent type of factory. In the continuous process factory the method of the control of the issue of material going directly into the product is a somewhat simpler problem. Here it is usually only necessary to issue orders that certain quantities of specified materials shall be issued each day to the proper departments. As the storekeeper or

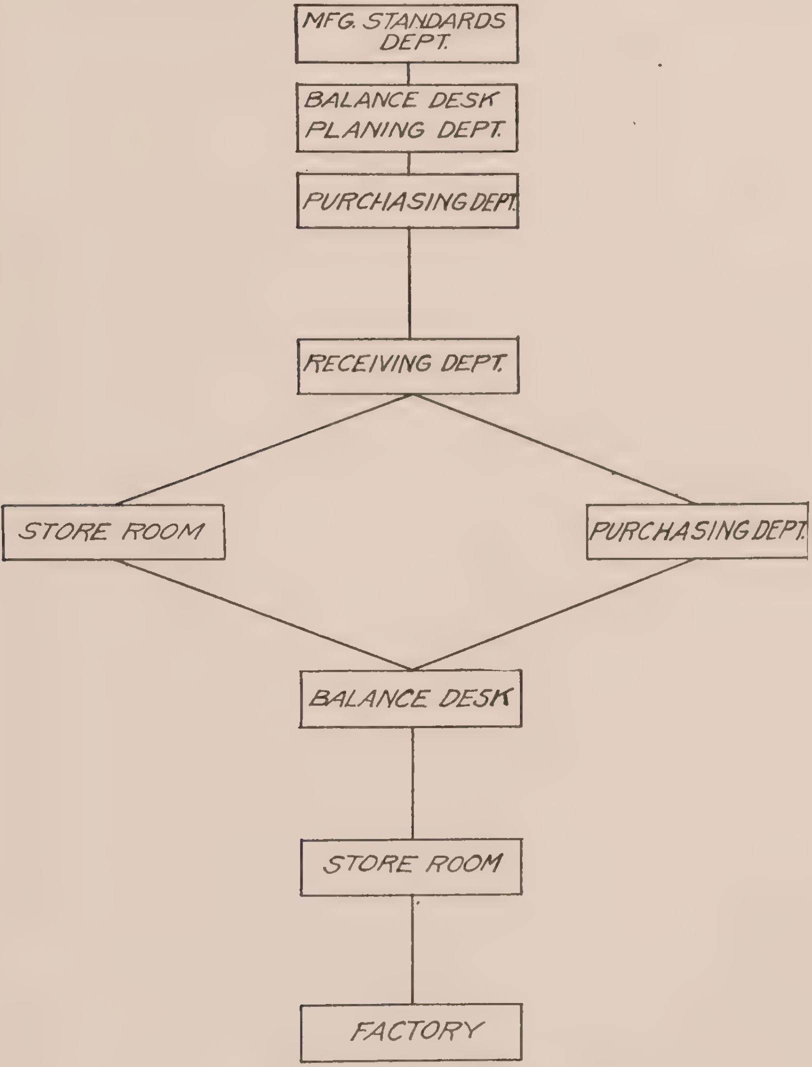


Fig. 72.—Materials Control Chart.

his assistants send out these materials, a record is made of the quantities issued. This report is used for making the necessary entries on the balance cards, and for conveying needed information concerning materials to the Cost Department. Such a method does away with the necessity of making out a separate issue every time material of this sort is wanted. Of course, for supplies, repair parts, and materials of like nature, individual issues are necessary even in a factory of the continuous process type. The chart shown on page 293 gives a perspective of the general control of purchased materials.

References for Additional Reading.

Basset and Heywood, "Production Engineering and Costkeeping," Chapter III.

Cartmell, M., "Stores and Material Control," Chapters II-VI, XI, XV-XVI.

Farquhar, H. H., "Factory Storeskeeping," Chapters IV-V.

Porosky, M. H., "Practical Factory Administration," Chapter V.

Chapter XXIII

BUYING MATERIALS

Purposes of this chapter.—

1. To outline the problem of purchasing material for a manufacturing concern.
2. To study some typical methods of a Purchasing Department for:
   a. Purchasing the right material.
   b. Purchasing at the right time and price so as to secure the greatest net value to the company for the money it expends.
   c. Securing delivery thereof at the time when it is needed.

Of course, it is also necessary for the department to buy other things than materials, such as services of various kinds—power, telephone service, transportation, etc.—but its principal task is to buy materials.

Requisites for satisfactory purchasing.—In performing the functions listed above it is necessary for the Purchasing Department to have complete and satisfactory specifications, a knowledge of markets and market conditions, to be well acquainted with the various vendors and the possibilities and limitations of each, to be thoroughly familiar with the needs of the factory and the kind of work for which the material is desired, to have accurate and up-to-date information of the status of material on hand, in use, and required, and to be provided with satisfactory methods for handling the routine work involved in its tasks. It may be seen that the scope of its work is broad and involves contacts both with other departments within the company and with outside concerns. Figure 73 shows in diagram form the control of purchasing.

The purchasing department needs accurate specifications.—It is impossible to purchase materials unless definite knowledge of what is wanted is at hand. Yet all too often it will be found that materials are bought on only the most meager information as to what is desired or the use to which it is to be put. Carefully prepared specifications are the starting point for sound purchasing. It has already been pointed out that the Engineering Department has the task of preparing specifications for materials which enter directly into the product. Such specifications for purchased materials should be checked up by the Purchasing Department, however, to make sure that they do not contain requirements which unnecessarily increase the difficulty of securing materials or raise their cost. All this means that the purchasing agent should be well enough trained technically to be able to talk intelligently on this subject with the members of the Engineering Department.

It is equally essential that the specifications be such as to meet the needs of the shop, and hence consultation between the purchasing agent and production engineer are frequently necessary; the purchasing agent should be sufficiently familiar with shop practice to be able to understand the effect which the choice of materials has on shop problems.

Market knowledge is an essential to sound buying.—Successful buying depends also on a thorough knowledge of the markets in which the needed materials can be secured. If the company employs a variety of materials in the production of its goods, the necessary market knowledge is apt to be large and only to be gained by long and painstaking study on the part of the buyer.

Within the available markets it is essential for the purchasing agent to familiarize himself with the various vendors and their peculiarities. Some, he may learn, are never worth considering, while others are most reliable and can be depended upon to live up to their agreements. Such knowledge is absolutely essential if trade connections are to be built up upon which the company can rely. It is being recognized now that quality and service are more important in most cases than price in the purchase of materials.

The effect of the business cycle on purchasing.—Closely allied to the general question of markets is the problem which is raised by what is now commonly called "the business cycle." It is a well-recognized fact that business conditions vary in a more or less regular fashion, dull times succeeding busy ones

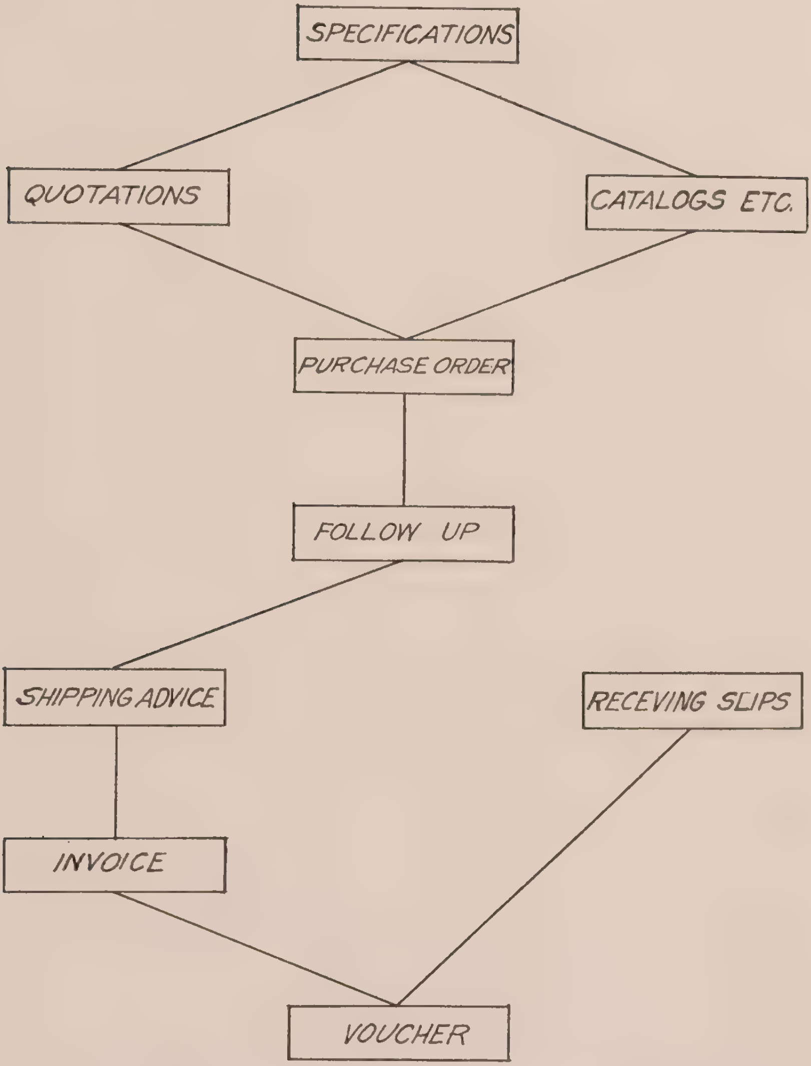


Fig. 73.—Material Purchases Control Chart.

through periods of transition. Each particular industry has its own cycle and its own peculiarities in regard to the duration of the sucessive periods. It is essential, therefore, for the purchasing agent to be familiar with the general business cycle and also with the particular cycles of the industries with which he comes into contact. It may be that his own company is entering a period of depression when concerns from which he buys a large part of the needed materials are approaching a time of prosperity. Evidently his course of action under such circumstances is bound to be different from what it would be if the reverse were true. To buy to advantage, therefore, it is essential for the purchasing agent to be a close student of the business cycles.

The purchase schedule.—It is necessary, however, for the purchasing agent to be acquainted with the needs of his company, not only in regard to the kind of material wanted, but also to the times when it is necessary that it should be delivered. In a general way, this information can be obtained from the master schedule on whose organization the purchasing schedule has had an effect. It has been pointed out that the purchasing schedule can provide for only a comparatively few of the many items which the Purchasing Department must buy. When material is wanted, the usual way to start in motion the regular procedure for securing it is for a clerk at the balance desk to write a purchase requisition which is sent to the Purchasing Department. If the article requested is not on the purchase schedule, the first information which the Purchasing Department receives concerning it is through this requisition. There is usually no connection between it and the schedule. If the purchase requisition is for material on the purchasing schedules, it is necessary to reconcile these two means of control.

At first glance this may seem to be a difficult task, but in most cases it is not so, for the requisitions are simply one means of fulfilling the purchasing schedule. It is customary to write a contract for material based on a purchasing schedule in such a way as to give it a certain amount of flexibility, in all cases in regard to dates of delivery, and in some instances in respect to materials. The purchase requisitions calling for specific quantities of material to be delivered at definite times provide a basis on which the purchasing agent can advise his vendors as to definite quantities and times of delivery. If more material is requisitioned than has been scheduled and contracted for, then it is necessary for the purchasing agent to cut into the open market and buy unless he can make special arrangements with his vendors, which, in some cases, is not possible. If less material is requisitioned than has been bought on schedule for that period the purchasing agent can cut down the contract in some cases. It may be necessary to accept the material and in this way a supply is built up in the storeroom which can be drawn on later, though it is wise to avoid an excessive inventory if possible. In some instances the buyer can sell the excess of the material over which he has control to other concerns and so relieve the company of what might otherwise be a burden.

It is not necessary for a purchasing agent to buy material in advance even though it is scheduled, unless he deems it wise to do so. He is held responsible for procuring a sufficient supply when he has been notified beforehand in time to obtain delivery, and he should secure this material on the most advantageous terms possible for the company. It may well be that prices are falling and hence it is wise to buy only as needed to meet the requisitions sent to the Purchasing Department by the balance of stores clerks. This does not mean that the schedule is of no use under such circumstances, for it still serves as a means of showing what is likely to be required for some time in the future and is immediately brought into play as soon as it becomes necessary to purchase for some time in advance.

In any event, however, the combination of purchase schedule and purchase requisitions gives a high degree of control over the more important materials. The schedule is the forecast of the future and the requisitions show how closely the actual purchase requirements approximate the forecast. While the requisitions are the start of many manufacturing orders, they are also the end of one step in the control of purchases.

Purchasing procedure.—When a purchase requisition is received by the Purchasing Department it is necessary at once to take steps to procure the desired goods. The procedure to be followed depends upon the conditions surrounding the requisition and the goods called for. If the materials are those which have been contracted for in advance on the basis of the purchase schedule, all that is necessary to do is to note on the purchase requisition the number of the purchase order on which it is to apply, send a notation of this to the balance desk, and record the requisition against the schedule. If the requisition calls for some relatively small items which are to be bought in the open market, a brief investigation of prices may be all that is necessary before the purchase order is placed.

Obtaining bids for material.—If, however, the requisition calls for material of considerable value or if it is a question of placing a contract for some item on the purchase schedule, it is then essential to act carefully, for the effects of any action taken are likely to be weighty. The first step is usually to secure bids from several different suppliers on the material wanted. It is customary to send out information as to what is desired to a number of vendors who are likely to be interested. Such requests for bids should contain detailed specifications of the article sought, the quantities needed, and the dates on which deliveries must be made. The information should be complete, as otherwise it is impossible for the company bidding to make an intelligent offer. It is useless to obtain bids on materials which are not capable of meeting the expected needs; it wastes the time of both the new buying and bidding companies.

While it is not desirable to secure offers on goods which are not utilizable, it is sometimes well to ask the bidding company if they make regularly material which approximates that called for in the bid and to request that specifications of any such articles with the price thereof be included with the bid. It frequently occurs that a concern will call for material which does not differ in any essential particular from that which regularly is produced by the company which is called upon to make a bid. In most cases the standard material of the supplying company can be purchased for less than any which is made to order. In addition, standard material can be obtained more quickly than special items and, in case of need, this is an important matter. In some cases, therefore, it may be wise to change the specifications so as to make possible the use of the standard material.

When all the bids are in it is necessary to compare them and make a selection from among them. It does not by any means follow that the company which makes the lowest bid will get the contract. Other things beside price (including transportation charges) must receive consideration, especially quality and reliability of delivery. A company which has established a reputation for the quality of its goods and for dependability in making deliveries upon agreed dates will often obtain a contract against the company which offers a lower price, but which does not give service along with the goods. A company is not so much interested in buying a certain quantity of material as it is in buying the service which that material can render, and in particular that kind of service which not only satisfies customers who buy the finished product but also keeps costs of production at the lowest possible figure. Both quality and reliability in making deliveries have an effect on the costs of fabrication. The quality of the material used will affect the setting and maintenance of the manufacturing standards, while failure to make deliveries when agreed is one of the fruitful sources of the breaking down of schedules with all the attendant bother and expense. The purchase order should be sent, therefore, to the company whose bid in connection with reputation which they have established through previous dealings gives evidence of being the most desirable from the point of view of the buying concern.

It is sometimes good policy to give orders regularly to a particular concern even though, from time to time, the same goods might be obtained for somewhat less elsewhere. There is a tendency to build up trade connections in this way which are often very helpful to both parties. The buying concern is sure to obtain better service in regard to both quality and delivery than is the occasional customer, and in times of very active business, when it is difficult to obtain materials anywhere, it will be able to secure them. The vendor, on the other hand, can well afford to render the steady buyer services in return for regular business and at reduced selling cost, while both concerns benefit by being able to plan their schedules to better advantage.

The purchase order.—When a definite bid or bids for—if the quantity of material to be purchased is large the orders may be divided among two or more bidders—have been accepted it is necessary to prepare and send out the purchase order. This should be done carefully in order to make sure that exactly what is wanted is ordered, that delivery dates are correctly specified, and that all other essential information is accurate. It must be remembered that a purchase order when accepted by the vendor becomes a contract legally binding on both parties. It is important that it shall say what is meant and be tangible and concrete evidence of the meeting of the minds of the parties concerned.

Following up purchase orders.—The placing of the purchase order by no means ends the task of the Purchasing Department. There still remains the duty of following up the order to insure the delivery of the material. It is useless to place an order unless delivery of the goods is secured, and, unfortunately, many concerns fail to live up to their promises unless they are constantly reminded of them. The problem follow-up is not so simple as it seems at first glance. The way in which it should be done depends on the kind of persons and the reliability of the company from which the goods are purchased. In some cases, a simple reminder card a week before the delivery date is all that is necessary to insure the receipt on the day specified. In other instances, it is necessary to set due dates some time in advance of the real time when the goods are desired, because it is realized when the order is placed that any promise of delivery must be discounted. There are two or three points in connection with the follow-up of purchased materials which should be noted. One of them is that it is useless to mark all orders sent out "rush." Vendors soon learn of this and fail to pay any attention to it. Hence when a real rush order is placed it does not receive the special consideration desired. It is also worse than useless to set a delivery date and then fail to follow-up if the goods are not delivered on time. This also gives the impresssion that the buying concern does not know what it wants. It is a matter of business courtesy to inform the vendor of any postponement of the need for the material which has been ordered so that he can modify his plans to advantage. It is also important not to follow up material which has already reached the factory, something which is sometimes done if the methods of material-control are lax.

Control of purchases in transit.—If there is no Traffic Department it is usually one of the functions of the Purchasing Department to continue the follow up of material after it has been shipped until it has actually been received at the factory. If the concern has a Traffic Department this part of the follow-up is its task.

Passing the invoice.—When the goods are shipped by the vendor, he ordinarily sends an invoice for them by mail to the purchaser. This invoice should be checked by the Purchasing Department for accuracy of price, quantity received, terms, etc. The invoice is then said to be "passed" and is sent to the Accounting Department where the extensions are checked and it is vouchered and filed for payment.

Goods which do not pass inspection.—If some or all of the shipment is unsatisfactory, it is usually returned to the vendor. If there is any question about the appropriateness of this procedure, the Purchasing Department should take this matter up by correspondence with the vendor. If the goods are to be returned this department issues the necessary instructions to that effect.

Purchase control forms.—So far little has been said about the mechanism employed by the Purchasing Department in the accomplishment of its tasks. The purchase requisition (see Figure 68) is the form used to convey to the Purchasing Department the request for material. It should contain the quantity of material desired, when it is desired, its symbol, specifications, or reference to blue-print, or specifications on file in the Purchasing Department, or have the specifications attached. It should be numbered serially for reference purposes.

On this purchase requisition should be added all the data which is to go on the purchase order (see Figure 69) which, in this way, serves as a first draft of the order, making it easy to correct any errors before the final draft is prepared. Among the items to be so recorded are: the name and address of the vendor, terms of payment, means of transportation, etc.

The purchase order is usually made out in quadruplicate. The first copy goes to the vendor, the second is retained in the Purchasing Department, the third is sent to the Receiving Department, and the fourth to the Accounting Department. It is desirable to record the purchase requisition number of the purchase order so that ready reference from one to the other may be effected. It is also wise to keep a register of purchase orders by serial number as the Purchasing Department's file of orders is usually arranged alphabetically by customers. The first copy which is sent to the vendor is the one which, when accepted, forms the contract. The copy which is sent to the Receiving Department is the authority for that department to receive the goods. On it is recorded the partial shipments, if there are any, and the receiving slip numbers so that the first record of the receipt of the goods may be located readily if needed. It usually passes by way of the balance desk in the Planning Department, so that a notation of the purchase order number may be made on the appropriate balance card.

The copy which is sent to the Accounting Department is used to compile statistics of the amount of the obligations incurred for future payment so that the treasurer may take the necessary steps to procure funds to be disbursed.

The copy retained in the Purchasing Department should be arranged so that attention may be called to it on certain dates determined in advance, when it is necessary to check up the order to see what progress is being made with it. On the back should be spaces for record of all receipts and often for the passing of invoices and return of unsatisfactory goods. It is the principal form used in the control of current purchases and care must be taken to see to it that it is well designed for the purpose to which it is put.

The receiving slip (see Figure 70) serves as a means of notifying the Purchasing Department of the receipt of goods in the Receiving Department. One copy should be sent to the Purchasing Department as soon as the goods reach the plant so that any further follow-up may be discontinued. The second copy follows after the goods have been inspected by the Stores Department and balance desk.

If any of the goods are rejected and returned to the vendor the Purchasing Department usually issues an order of the kind shown in Figure 71. One copy is sent to the vendor, a second to the Accounting Department so that the vendor's account may be debited, a third is packed with the material, a fourth is retained in the Shipping Department, while a final copy serves as an order directing the material to be sent to the Shipping from the Receiving Department.

In addition to these forms which are used for internal information principally, it is also necessary for the Purchasing Department to be provided with files of catalogues and current bulletins of concerns supplying goods which it uses. It is desirable to have current trade periodicals and be provided with charts like Babson's, Brookmire's, Harvard, etc., on which forecasts of the future may be based.

Standards of procedure.—The Purchasing Department has an important task to perform and many contracts to maintain. It is essential, therefore, that standard methods of procedure be developed so that the routine work can be probably carried on with a minimum of attention from those on whom the decisions in more important matters depend. This means that standard practice instructions must be prepared for such work and that the clerks must be adequately trained.

It must be remembered that the factory is useless with materials whose procurement is one of the first steps to be taken in the current production of merchandise. Hence, it is one of the key departments and should be treated as such.

References for Additional Reading.

Basset and Heywood, "Production Engineering and Cost Keeping," Chapter II.

Cartmell, M. H., "Stores and Material Control," Chapters XX-XXIX.

Dinsmore, J. C., "Purchasing Principles and Practices," Chapters I-VIII.

Farquhar, H. H., "Factory Stores Keeping," Chapter VI.

Kimball, D. S., "Plant Management," Chapter VI.

Lansburgh, R. H., "Industrial Management," Chapter XXXVI.

CHAPTER XXIV

RECEIVING, STORING, AND ISSUING MATERIAL

Purposes of this chapter.—

1. To study the methods of receiving material.
2. To investigate the problems involved in the storing of materials.
3. To study the problems encountered in issuing material.

There are two possible sources of material which must be stored temporarily—the factory itself which produces worked material, and the outside suppliers who furnish the stores material. The problems involved in the storing and issuing of these two groups of material depend upon the nature of the material and not upon the origin, and so no differentiation need be made between them in discussing these phases of their control. Their receipt, however, is usually handled in different ways.

As the worked material comes from the factory it is most convenient to take all the steps preliminary to its actual delivery into the store-room, such as inspection, making a record of the quantity received, etc., before it leaves the shop and hence little or nothing remains to be done except to move it physically to its storage space. The form on which the record of its receipt is made is shown in Figure 60E.

The location of the receiving department.—The problems involved in the receipt of stores material are a little more complex. One of these is the best location for the Receiving Department. It must be adjacent to the railroad track if there is one close to the factory. It must also be easily accessible to the road or street for much material is often delivered by motor truck. If electric railway and water transportation systems touch the company's property and are used for incoming material, it should be near them also. Obviously, it is likely to be difficult to find a location which is equally available to all these. In a large plant, it is frequently desirable to divide the Receiving Department, physically, into two or more sections and locate them where they can best receive incoming shipments.

The location of the Receiving Department with respect to outside contacts is only one phase of the problem, however. It is also essential for it to be close to the storeroom so as to reduce to a minimum the amount of handling of material after its receipt. This whole problem of the location of the Receiving Department can be solved only by analyzing carefully all the various pros and cons, weighing them judicially and making a selection which seems to make possible the maximum amount of service on the part of the department.

The steps in receiving stores material.—When materials arrive at the plant it is essential that they should receive immediate attention in regard to certain details, at least. In most cases it is necessary for the receiving clerk to sign a receipt of some kind for them, and in this way they are brought to his notice. There are times, however, when goods are left by a teamster who asks for no receipt and hence they are overlooked and neglected. There are several reasons for the need of caring for materials as soon as they arrive. It is very poor business to follow up purchase orders after delivery has been made. It causes trouble to the vendor and transportation companies and develops ill-will on their part. It is important, therefore, for the Purchasing Department to be notified as soon as the goods come in, and this can be done only if the Receiving Department records their arrival immediately upon their receipt. In many cases, also, the receiving platform is exposed to the weather and goods may often be spoiled if left there for any length of time. In other instances, no attention is paid to materials which have come in. They are pushed into corners and other articles are piled on top of them, and thus they are lost track of. Sometimes they are treated as lost altogether and other materials are ordered to replace them. If some record is made at the very beginning they are likely to be sought and found.

Hence, as soon as any material of any kind reaches the factory a receiving slip (see Figure 70) should be made out at once showing the date received, the name of the vendor, the purchase order number, and the quantity which the shipment is supposed to contain. One copy of this slip should be sent at once to the Purchasing Department to notify it of the arrival of the goods.

The inspection of incoming shipments.—The next step to take is to open and inspect the shipment. In some cases this can be done immediately upon the receipt of the goods. It often happens, however, that goods arrive irregularly, and that more come in in a single morning than can be inspected in several days; in such cases part of the receipts must wait. The inspection which is necessary depends largely upon the nature of the goods and varies from a rather casual measurement, to make sure that the approximate amount called for on the shipping advice has been received, to a careful inspection of each unit and the testing of samples in the laboratory. In some instances, inspectors of the buying company are stationed at the vendor's plant and no materials are shipped unless they are approved. Under such circumstances the only inspection necessary upon arrival is that needed to make sure that no damage has been incurred in transit. Almost always, however, the inspection is done after the goods have reached their destination.

The organization of the inspection of incoming material depends on the extent to which the inspection must be carried. If it is to be simply a count inspection with the elimination of any evidently spoiled and damaged units, then it is usually wise to allow the receiving clerks to do it. It is necessary, of course, to select clerks who are capable of picking out the unsatisfactory units and then train them in this work as well as in the regular work of receiving the materials.

If a more thorough investigation of the goods is essential, it is usually desirable to employ regular members of the Inspection Department for this purpose. In some cases they can perform their tasks on the floor of the Receiving Department, and in other instances it may be well to screen off a portion of the department for that purpose. This enables them to work more quietly and, if they employ expensive equipment, it affords protection for it. It also serves to make a more habitable place for the inspection, as in the winter time the Receiving Department is usually rather cold, since it is necessary to have the doors open so much of the time. Such a separation generally promotes more effective control of the workers also, as there is less opportunity for conflict of jurisdiction. Under any condition, however, no materials should be removed from the Receiving Department until they have been inspected and either passed or rejected, and no rejected material should be moved until definite orders for its disposal have been received. To do so creates a serious possibility that good and bad will be mixed again and thus necessitate the re-inspection of a much larger quantity of material than the original shipment in order to find and eliminate the unsatisfactory units.

The problem which is raised by placing inspectors in the Receiving Department is one of jurisdiction. It requires a spirit of coöperation between the chief receiving clerk and chief inspector to make the work flow smoothly. In most cases it is wise to allow the receiving clerk to decide in what order the goods are to be inspected, but in regard to accepting or rejecting the materials, the inspectors are responsible to the chief inspector.

In some instances it is essential to make laboratory tests of samples before the materials are definitely accepted. This necessitates sampling the goods, which is both a technical and a practical problem, and also making provision for space within the Receiving Department where the goods may be stored while the tests are made.

The disposition of the receiving slips.—When the goods have been inspected, the remaining copies of the receiving slip are made out. One copy should always be sent with the material to the Stores Department. Another copy is sometimes sent directly to the Purchasing Department to be used in the passing of the invoice and as the basis for issuing the necessary orders in regard to rejected material. A fourth copy is often retained in the Receiving Department as a record of the shipment. Rejected goods should be held until an order for their disposition reaches the Receiving Department.

The location of the storeroom.—The accepted goods are sent to the storeroom which should be equipped to receive them. The location of the Stores Department, like that of the Receiving Department, involves a number of problems. It should be conveniently near both the Receiving Department and the shops. A solution of a part of the problem, at least, is to divide the storeroom, physically, into a number of sections, locating, so far as possible, those in which worked materials are to be stored between the department producing the material and the one in which the material is to be used. Purchased parts can also be stored in these sections which are thus made feeders for the assembly departments.

It is generally good policy not to locate storerooms where they will occupy well lighted areas which are much more valuable as operating space. Hence they are frequently placed in the interior of the building with the manufacturing departments surrounding them. Such an arrangement also enables them, in many cases, to serve several departments conveniently. While it is desirable to have good light for all kinds of work it is not so necessary for the storage of materials as it is for the operation of machinery, and, in any event, fewer persons suffer if the storeroom is not well lighted than if the shops are inadequately equipped in this respect.

It is often desirable, therefore, to use the basement of the factory for storage purposes, for it has certain additional advantages over and above those mentioned. If adequate foundations have been put in, there is practically no limit to the weight which can be stored on a given area in the basement, while this is often a controlling factor in the case of storage space on upper floors. As the Receiving Department is usually on the first floor of the building, this arrangement also means that gravity can be used to transfer much, if not all, of the material from this department to the storeroom.

To decide upon the proper location for all of the sections of the storeroom it is necessary to analyze all of the factors involved, evaluate the various possibilities, and check the results before making any final decision. In any location, the storeroom must furnish adequate protection against fire, theft, and deterioration of the goods, act as a reservoir for materials not yet actually needed in the shop, and prepare them for issue when the time comes that they are wanted.

The storeroom equipment.—The equipment which the storeroom uses for the storage of the material is one of the most important details which is involved in the proper storing of the goods. It is essential that material be protected from damage, that it be easily accessible, and that old material be used before the new. For small parts such as screws, nuts, bolts, etc., bins and drawers can be employed to advantage. For bar stock, automobile tires, and many other large parts, racks and frames are very useful. In many cases it is possible to design them so that they can be knocked down when not in use and the space which they were occupying be for other purposes. This gives a flexibility to the storage room which is very advantageous. Liquids are usually stored in the containers in which they are received, such as cans, barrels, carboys, etc., or in permanent tanks. The cans and carboys can ordinarily be placed on shelves while the barrels frequently require racks, especially if the liquids which they contain are to be issued in small quantities. The variety of available means of storing the goods is large and offers an opportunity to select what is needed to advantage.

The layout of the storeroom.—The accessibility of the material depends largely on the way in which the storeroom is laid out. Main aisles should be provided of such width that two trucks can pass each other easily. Side aisles are usually adequate, if they provide space for only one truck at a time, unless they are unusually long. In some cases alternate side aisles may be used for loading and unloading the materials.

It is most logical to lay out the storeroom in the order indicated by the symbols of the materials. In a general way this plan holds good in practice, but it is usually necessary to modify it in certain respects. Materials which weigh much per unit should usually be kept on or near the floor. Light articles per unit can be raised often as high as the construction of the building will permit. It is ordinarily wise to keep goods which are used most frequently near the entrance so as to be easily accessible. Such factors modify the general plan of arranging the materials according to their symbols.

It is also essential to give some attention to the arrangement of the storeroom from the point of view of permitting the oldest material to be used up first. There is scarcely any material which does not deteriorate to a certain extent from storage. In many cases the rate of deterioration is so slow that it is not noticeable if the goods are moved within a reasonable length of time. In other instances, it is essential that the articles remain in the storeroom only a short time if they are to prove satisfactory when used. Even though the material may deteriorate very slowly, its design may be changed slightly from time to time without any change being made in the symbol. This should not be done, but it is, occasionally.

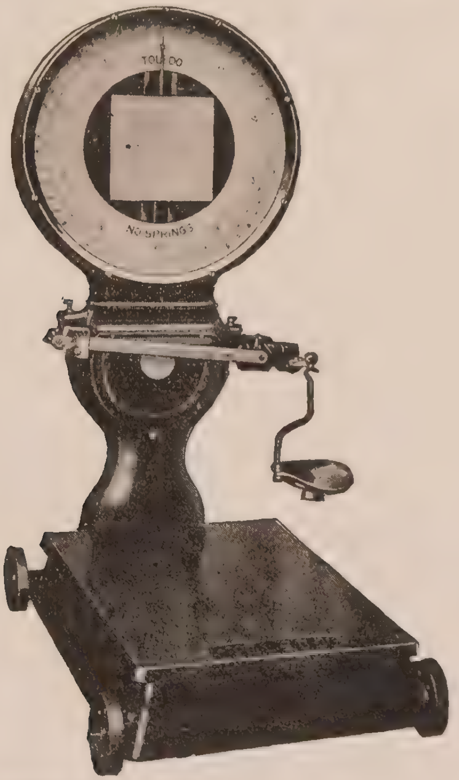
Nevertheless, the old parts, when the time comes to use them, are found to be worthless, because they will not fit with the parts with which they are supposed to be assembled—parts of which the design has quite likely been changed slightly also.

Double bins and hopper bins.—There are several arrangements which can be made to prevent such an accumulation of old parts. One method is known as the "double bin" system which got its name from the fact that it was first used with small parts. Two bins or storage spaces are provided for each kind of material. Material is put into one of these until a call for it is received. It is then issued out as needed while additional receipts are placed in the second bin. Material is issued from the first bin until it is exhausted and it is then taken from the second bin while the receipts are now placed in the first bin. In this way the two bins are employed alternately for the receipt and issue of material and so none is allowed to accumulate for any length of time.

Another method is known as the "hopper" system, because it also was first used with small parts which could easily be placed in a hopper. In this arrangement the goods are put in at the top of the bin and taken out from a hopper at the bottom. Thus a circulation of material is secured. The same effect can be obtained if the materials are put in at one side of a shelf and pushed through to be taken out from the other side.

This second method is generally more desirable than the first where it can be used. It has distinct limitations, however, because many materials cannot stand such handling. There is also a certain tendency for materials to collect in the corners and not be issued. The double bin system necessitates more space, though not twice the space of a single bin system, since there are two storage spaces instead of one. It is more adaptable to a variety of uses, for any storage device can be duplicated if there is room for it. Racks, shelves, etc., can be planned on the double bin system quite as well as bins. By some method, however, it is highly desirable to provide against the accumulation of old material.

The issue of materials.—After material has been received and stored there is still the problem of issuing it for use. At first glance this may seem to be quite simple and often no particular difficulties are encountered, but sometimes the difficulties are serious. The problems of material issue center largely around the measurement of the goods. Take, for example, the issue of 5000 wood screws of any of the medium sizes. It is obvious that it is possible to count out these screws by hand, but such a job would cost almost as much as it costs to make the screws in the first place in an automatic screw machine. The most satisfactory way of solving such a problem is to use a counting scale (see Figure 74). On such a scale 10 or 100 screws can be counted out by hand, and the scale so set that when the same kind of screws are placed on the scale pan, 1000 screws will just balance the 10 or 100 screws which have been put in the weight pan. If the screws were made with considerable accuracy, there would not be more than one off from one thousand in such a measurement. Under normal

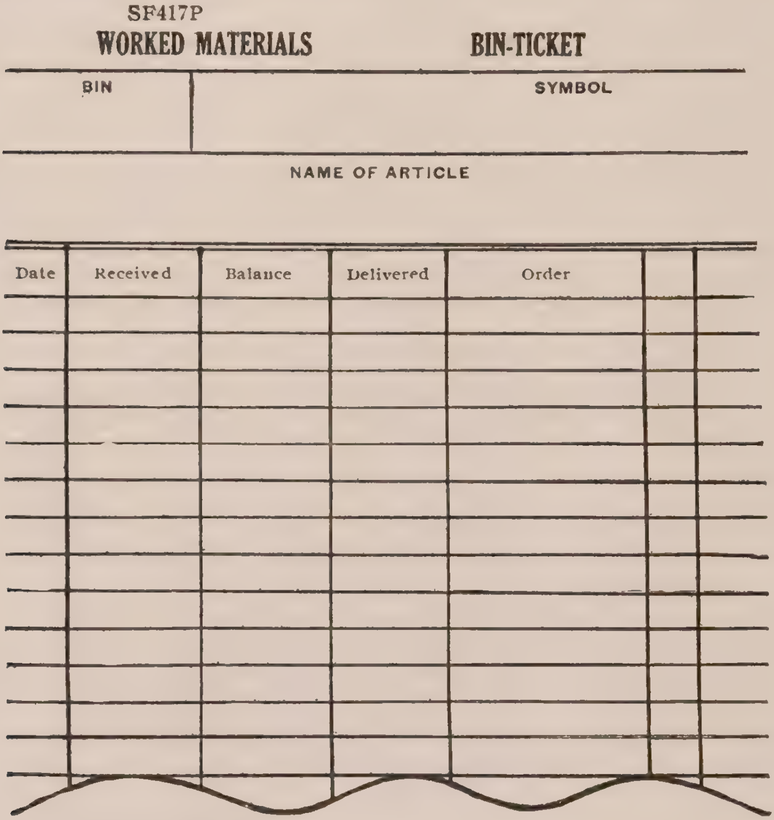


By Courtesy of the Toledo Scale Co.

Fig. 74.—Counting Scale.

conditions there would probably not be an error of more than two or three, only a fraction of one per cent, and such a measurement would be much more accurate than a hand count.

It might seem as though such a device would solve all the problems of counting small parts. There are cases, however, where it is not wholly satisfactory. The measurement of small paper parts is one instance of this kind. When such parts are made their weight is affected by the atmospheric conditions of the moment. They absorb moisture from the air and take on weight during damp weather and dry out and lose weight in dry weather. When in storage, the top layer protects the others from the effects of the atmospheric conditions of the day. Hence if parts are made in damp weather and issued in



SF417P

WORKED MATERIALS BIN-TICKET

BIN

SYMBOL

NAME OF ARTICLE

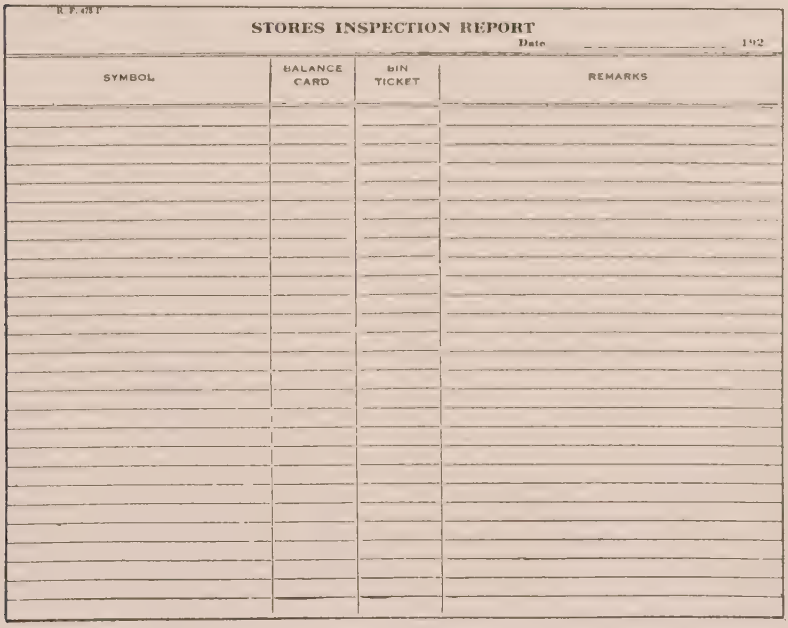
Date	Received	Balance	Delivered	Order		

By Courtesy of the Acme Wire Co.

Fig. 75.—Worked Material Bin Tag.

dry weather and the counted parts are taken from the top of the bin, too few will be issued. If the reverse of the weather conditions holds, too many will be sent out. This same kind of problem in many forms is encountered in many different factories.

It is also important, when issuing material, to have it so arranged that it can most easily be used in the shop. This is especially true in the case of assembly material. All the parts should not be thrown helter-skelter into a tote-box or on to a truck. It takes no more time to put them neatly and arrange them in definite places on the truck than it does to throw them together, and orderly arrangement at the time of issue means much time saved during assembly. Not infrequently it will be found advisable to design special trucks with definite places for each part so that a standard method may be adopted for issuing and using assembly parts.



STORES INSPECTION REPORT

Date ________________ 192

SYMBOL	BALANCE CARD	BIN TICKET	REMARKS

Fig. 76.—Stores Inspection Report.

Material issue forms.—The forms which are used in the storeroom are simple. The receiving slip (see Figure 69) and worked material in-slip (see Figure 60E) have already been described. Material should only be sent out on the strength of a written order which usually takes the form of a material issue (see Figures 60A and C and 63). When material is returned unused, a record thereof is made on a credit slip (see Figures 60B and D). In the storeroom itself a perpetual inventory in the form of a bin tag (see Figure 75) is often maintained.

Inventories.—Under most circumstances it is not desirable to try to take a complete physical inventory at any one time. The likelihood of errors is so great that it renders the results practically valueless. It is much better practice to verify constantly the perpetual inventory represented by the "on hand" section of the balance card. The more extensively an item is used, the more frequently it should be checked, and all items should be inventoried at least once in the course of the year. The form which is used for this purpose is shown in Figure 76. It will be noted that spaces are left for the last entries on the bin tag. This is to make possible a reconciliation between the bin tag and the balance card, for the entries are always made on the bin tag a half a day or a day before they are recorded on the balance card. Of course, if all the transactions which should affect both records are not considered they can hardly be expected to agree. When a count and checking of this kind is combined with an adequate cost accounting system, annual physical inventories become quite unnecessary.

Conclusion.—The whole problem of material control is one of the most important phases of the control of production. If materials can be really controlled a large part of the difficulties in the management of the operating departments has been overcome, for, in a broad sense of the term, the control of materials *is* the control of manufacture itself.

References for Additional Reading.

Cartmell, M., "Stores and Material Control," Chapters XIII, XIV

Farquhar, H. H., "Factory Stores Keeping," Chapters VII, VIII.

Lansburgh, R. H., "Industrial Management," Chapter XXXV.

"Library of Factory Management," Volume III, Chapters VII, XV, XVI.

Twyford, H. B., "Storing," Chapters V-VII, IX-XII.

CHAPTER XXV

DISPATCHING WORK THROUGH THE FACTORY

Purpose of this chapter.—To study the problem of dispatching work through the factory.

In planning and scheduling production, all the preliminary steps in the control of production are taken and the way is prepared for the actual accomplishment of the work of the shops. Dispatching is the giving of the signal at the proper time to begin work, for unless the work is dispatched or started all the plans and schedules amount to nothing, the equipment and the workers are idle and nothing is accomplished. It is evident from this that dispatching is being done all the time in every factory, large or small, continuous, intermittent, or jobbing type, whether it is well or poorly organized. In a great many instances, probably in the majority of concerns, dispatching is being done quite unconsciously, but nevertheless actually, for otherwise work would soon cease. Whenever an order is issued, work is dispatched. However, an order is not fully or completely dispatched unless it is followed up to make sure that it is being executed. So dispatching includes not only the giving of orders, but the checking of their progress by means of reports of one kind or another.

Dispatching.—Dispatching, therefore, is an ever-present, ever-recurring activity, not only in the shops, but in all the various departments of the business as well. In planning and scheduling production a certain amount of dispatching must be done, as, for instance, when orders are sent to the Tool Designing Department to design a certain tool and later another order is sent to the Tool Manufacturing Department to make that tool, and these orders are followed up to make sure that they are completed in time. The dispatching as well as the scheduling of both of these orders and the work done upon them is a part of the planning and scheduling of the production of the merchandise in the fabrication of which the tool is to be used. Planning, scheduling, and dispatching are simply three closely related phases of the control of production, all of which are ordinarily carried on simultaneously and by varying methods.

From one point of view, dispatching is the putting into effect of the schedules which have been prepared, for a schedule resembles in certain respects a railroad time-table, and the dispatching of work according to the schedule is similar in some ways to the dispatching of a train in accordance with the timetable. Dispatching all the work through the factory is somewhat like dispatching all the trains on a railroad system. They must be dispatched so that they will pass where the road is double-tracked and some of them must meet at certain junction points. This same idea holds true in regard to the factory. The various orders must be dispatched in such a way that no two will be assigned to the same machine and the same worker at the same time, or the workers be expected to use the same material.

Dispatching, a coördination in respect to time and place.—Dispatching work through the factory involves the coördination in respect to time and space of equipment, materials, workers, and instructions. Unless this coördination is accomplished no work is done. In most cases the equipment establishes the place, for most machinery remains in a fixed place and the other elements of production are brought to it. The time is determined by all four of the elements together.

Dispatching in a continuous process type of factory.—When the practical problem of dispatching is investigated it is found that its difficulty varies greatly from industry to industry, and that the methods to be employed must be adapted to the needs of the particular situation. In the continuous process type of factory the technical details of dispatching are reduced to a minimum as is true for scheduling in this same kind of industry. The machinery remains in one place and is either operating or idle. If it is kept in good condition, as it should be, it is ready and capable of doing all the work which is assigned to it up to its scheduled capacity. The workers are assigned to particular production centers and should remain there as long as the factory continues in operation unless something occurs to upset the normal course of events. Either the machine needs no tools or the tools which are used in conjunction with it are delivered to it regularly. The raw material, whatever kind it may be, is usually dispatched by issuing an order to the Stores Department each day to send out a certain quantity of material, and such an order should stand until another order is issued changing it in some way. Each production center should be equipped with standard practice instructions explaining how the task is to be performed, and such instructions should ordinarily be left in charge of a foreman, but should be available for the use of the workmen at all times.

Some such plan as this provides for the dispatching, in the first instance, of the work of the factory. It is also essential that a record be kept of the output of each operation, or, at least, of each "key" operation each day, and in this way any failure to live up to the standard rate of production can be instantly detected and the attention of the superintendent called to it at once. All this represents a rudimentary form of dispatching, but it is usually all that is needed in the continuous process type of industry.

Dispatching in the jobbing type of industry.—When the jobbing type of industry is considered it will frequently be found that the problem is complex, for it is necessary to bring many different orders into a proper relationship with respect to the four groups of factors to be controlled. The whole matter is further complicated by the fact that there is little or no time to consider varying possibilities when the moment comes to dispatch some of the work. A report is received that a certain job has been completed; it is necessary to dispatch a new job at once or men and equipment will remain idle and the forward progress of work in the shop will be checked.

The dispatch mechanism which is described in the following paragraphs is not given as a general method applicable in all cases, but one which is typical of the sort which may be used to advantage in handling the dispatching problem in this kind of industry. It is presented as an illustration rather than as a model.

The dispatching of equipment.—The equipment is one of the first factors to be considered in dispatching work through the factory. In general, if divisible at all, it may be divided into two parts—machines and tools. Both of these need to be dispatched in many instances. If the machine requires no preparation after the completion of one job before another is sent to it, then all the dispatching which is needed in this connection is performed in sending materials, workmen, and instructions to it. If, on the other hand, as in the case of a punch press, it is necessary to prepare the machine for the next operation and that preparation requires any special skill or length of time, then it becomes necessary to issue orders for its preparation. In the case cited, the die must be procured before the press can be set up. There are two possible ways of dispatching the tools to the punch press. One of them is to send an order to the tool crib directing the delivery of the tools to the proper machine. The other way is to send out instructions to set up the machines, the instructions indicating what tools are necessary and leaving it to the worker who receives the instructions to go for the tools. The worker, usually a set-up man or sub-foreman, can be dispatched by sending out a time ticket assigning him to the job, and the instruction card directing how the machine shall be set up.

The dispatching of material.—The dispatching of the material to the job is another step in the control of the progress of the work through the plant. In the jobbing type of factory this is usually accomplished by means of material issues, which have already been discussed in connection with the control of material. These issues (see Figures 60A and C, and 63) call for specific quantities of material and should be filled as soon as they are sent to the storeroom, a sufficient length of time being allowed for the physical handling of the material. These issues should also indicate the machine or group of machines to which the material should be delivered, and hence can be made to serve as orders for the transportation of material to the first operation as well as a demand for its issue. These issues are ordinarily sent out by the dispatch clerk who, in this way, starts the material on its course through the factory.

The workers are ordinarily dispatched by means of the time tickets (see Figure 62B). These time tickets indicate the order to be worked upon and the machine on which the job is to be done. By putting the worker's name or number or both on the time ticket, the employee is definitely sent to a particular task. All of these tickets form a part of the system of orders by means of which the work is dispatched. The orders and instructions are completed, in so far as the actual accomplishment of the task is concerned, by the issue of the instruction card which usually accompanies the time ticket or is delivered to the worker with the tools.

The control of first inspection.—As soon as the worker begins a new task it is wise to make sure that he is doing it properly. It is a tremendous waste to allow a man to spoil all or a large part of the material which is sent to him, for not only is the value of the raw material entering into the product lost, but also all the value of the labor and earned burden which has been impressed upon the goods before they reach the operation in question. Hence, it is desirable, in many instances, to dispatch an inspector to the job as soon as it is started to make sure that the quality of the output is acceptable. This is done by sending an inspection ticket (see Figure 62E) to an inspector who should immediately inspect the output and approve it if it is satisfactory. If it is not, then he should hold up the job until the machine has been so adjusted that the output is all right.

The dispatching of the final inspection.—When the job is completed, the inspector should inspect the completed articles. In some cases, it is necessary to move the material to an inspection booth, and this involves the dispatching of this transportation by means of a move ticket. In other cases, the inspector inspects the goods where they are on the floor and they are not moved to the next operation until they are approved by him. If they are not carried to an inspection booth after inspection, it is necessary to dispatch their further movement by means of another move ticket.

Dispatching the movement of materials.—The move ticket (see Figure 62C) is an order to a move-man to transport the material from one work place to another as indicated on the move ticket. The dispatching of the move ticket is an indication that the material is ready to be transferred and should be moved at once. Of course a reasonable amount of time should be allowed for the movement of the goods after the move ticket is sent out. If there is any special need for immediate action, the ticket may be marked "rush" and the material referred to should then receive immediate attention.

Following up dispatched orders.—The actual dispatching, it has been noted, is accomplished by sending these various suborders to the individuals who are to perform the tasks specified. It is essential to the control of production that these same orders be returned to the dispatch clerk as soon as the work called for is completed. It is only in this way that the dispatch clerk can keep track of what has been done and so know what it is possible to do next. In this way these various tickets serve as reports in addition to acting as orders.

The relation of the dispatch clerks to factory foremen.— In one sense of the word, the term "order" is a misnomer as applied to time tickets, inspection tickets, move orders, etc. If they are full and complete, carrying with them the significance of compulsion, the result would be to place workers, foremen, inspectors, etc., under the control of a dispatch clerk and to reduce the position of superintendent to a mere nonentity. It would be found that a clerk would be issuing orders to men who were drawing, in some cases, twice his salary and, presumably, carrying much greater responsibility than he. Obviously this would hardly be sound practice. The Planning Department is essentially a service department whose chief task is to facilitate the successful operation of the direct manufacturing department. To this end it has been given tasks which, presumably, it can perform to the better advantage of the business than if they were left to the direct manufacturing departments, especially the work of forecasting the needs of the factory and deciding in which order various jobs are to be performed.

It is often a delicate problem, however, to decide just how far the authority of the Planning Department, as represented by the dispatch clerk, should extend. If it is given no authority, its requests are likely to be disregarded and its work rendered useless. If it is given complete authority, the superintendent and foreman are likely to become disgruntled and coöperate as little as possible. It is usually wise, therefore, to treat the orders sent out by the dispatch clerk as recommendations, with the understanding that they are to be followed unless the foreman or some one else who has been given the privilege of making a decision in this matter decides that there is a good reason for not doing as requested. Not infrequently the foreman on the spot is in a position to foresee some impending trouble and be able to take steps to ward it off. If the proper spirit of coöperation among the holders of the several positions exists, the foreman will immediately take the matter up with the dispatch clerk, and they will arrange it together. If the control of the situation is beyond them, they should refer the matter to their superiors—the superintendent and the production manager.

If, however, there is a disagreement between the foreman and the dispatch clerk, the question should be taken up with those over them, and the latter should adjust the matter between them, if possible. If they cannot reach a common understanding the problem should be turned over to the factory manager. In this way the foreman can feel that he does not have to take orders from the dispatch clerk and that, if his reasons are sound, he will be upheld in the stand which he takes. On the other hand, he cannot block the decisions of the Planning Department indefinitely, for, whenever he refuses to do as requested, his refusal must pass the review of a higher authority and if his reasons are not justified and he is evidently trying to cause trouble, it should not be long before he is replaced by another. If the proper attitude exists among the lesser executives, there should be very little occasion for the judicial function being exercised. The foreman and dispatch clerk should realize that their interests lie along the same line and that good results can be attained only by working together harmoniously.

The location of the dispatcher.—The matter of the satisfactory coöperation of the foreman and the dispatch clerk has considerable bearing on the physical location of the dispatcher. There is little question but that, from the organization's point of view, production dispatching is a part of the work of the Planning Department. It does not follow from this, however, that the dispatch clerk must necessarily be located in the Planning Department. In many instances it is more satisfactory to construct a dispatch booth in the shop, one for each department or for every two departments, if there is not sufficient work in one department to keep one man busy all the time.

The advantage of having the dispatching done from a booth within the department is that it facilitates the coöperation between the foreman and the dispatch clerk. It enables the men to come directly in contact with the clerks when they come for their tickets and promotes that close relationship which should exist between the planning of work and its actual performance.

It also saves the cost of the installation of a pneumatic tube or some other system of communication which is necessary if the dispatching is to be done from a central Planning Department. This latter method of dispatching, however, has the advantage of bringing together the scheduling of production and the putting into effect the schedules by dispatching. The choice to be made between these two possibilities depends largely on local conditions.

Determining the time to dispatch orders.—The kinds of orders used to dispatch the work through the factory have been described, but the important point of how to determine the time when these suborders should be sent out has yet to be discussed. The basis for practically all dispatching is the production schedule in its various forms. If the schedules have been properly prepared and an adequate margin of safety provided, there should be no reason why the dispatching cannot be done according to schedule. When the schedule shows that a certain order is to be started on a particular date the various suborders used by the dispatch clerk should be withdrawn from the files in which they have been stored since their preparation, and given to the dispatch clerk. He should at once send the material issues to the storeroom and place the time tickets, inspection tickets, move tickets, etc., on his dispatch board in their proper places.

The dispatch board.—The dispatch board in one form or another is an important part of the equipment with which the dispatch clerk is provided for the accomplishment of his task. One form of this dispatch board has two or three sets of hooks or clips for each production center in the shop. If there is only one unit of any kind of equipment, three sets of hooks are provided; if there are several production centers in a single department which are all alike two sets of hooks are supplied each production center and a third set for the group, though frequently there are so many tickets to be placed on this third set of hooks that several sets must be arranged for a group of production centers. On the top set of hooks for each center are placed the tickets for the job actually being worked upon at the moment. On the second set of hooks are put the tickets for the jobs, the materials for which have been moved to the production center and which are ready to be worked upon as soon as the job in process is finished and the machine can be prepared. On the third set of hooks are hung the tickets for jobs which have been started in the shop, but which have not yet reached the production center.

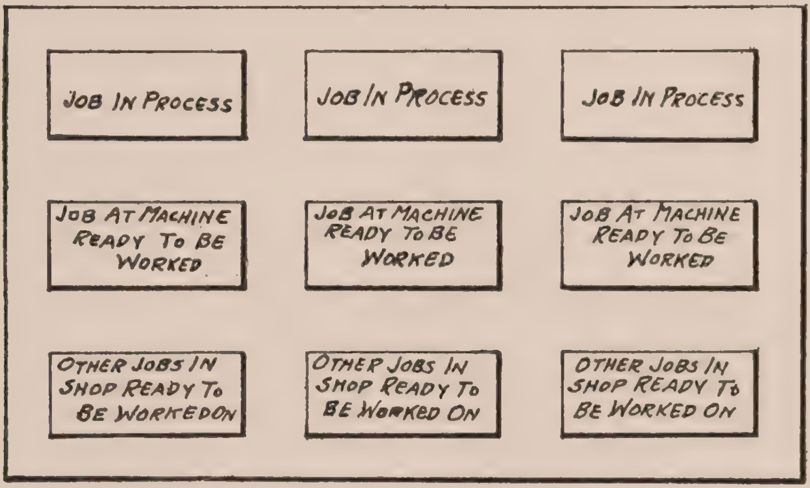

JOB IN PROCESS
JOB IN PROCESS
JOB IN PROCESS
JOB AT MACHINE READY TO BE WORKED
JOB AT MACHINE READY TO BE WORKED
JOB AT MACHINE READY TO BE WORKED
OTHER JOBS IN SHOP READY TO BE WORKED ON
OTHER JOBS IN SHOP READY TO BE WORKED ON
OTHER JOBS IN SHOP READY TO BE WORKED ON

Fig. 77.—Dispatch Board.

As the work on an order is started and the material issues are sent to the storeroom, the tickets for the order in question should be placed behind all the other tickets on the third set of hooks for each production center or group of production centers at which work on the order is to be done. When the material reaches the department from the storeroom, as is indicated by the return to the dispatch clerk of the material issue, the tickets for the first operation should be taken from the third set of hooks and placed behind the tickets on the second set. As the orders are worked on and moved away from the production center in question, the tickets for the order under consideration come to the surface and are moved to the top set of hooks when the set-up ticket is sent out directing that the machine be prepared, or the time ticket is issued for beginning work on the job. When the first operation is completed and finally inspected, the move order is sent out to move the material to the next operation. This is a signal for changing the tickets from the third to the second set of hooks at this production center. In this way, the work is dispatched through the shop step by step, no step being taken until the one before it is reported complete by the return of the ticket directing that it be taken.

Controlling the order of work.—It should be evident from the above description that under normal conditions the dispatching of the work becomes more or less automatic. It is possible, however, to modify the sequence of operations by changing the sequence of the tickets for the different orders on the second set of hooks and thus altering the order in which the several orders are to be worked upon at any particular production center. The responsibility for some of these changes falls on the dispatch clerk. He should look over his board from time to time to see if there are not some work places where no work is waiting to be done. If there are any such production centers he should endeavor to arrange the work at the other centers so that another job will soon be ready for those which are likely to run out of work. He can tell the extent of the emergency by observing the time of starting stamped on the ticket for the job in process, the standard length of time allowed for the order at that operation, which should also be recorded on the ticket.

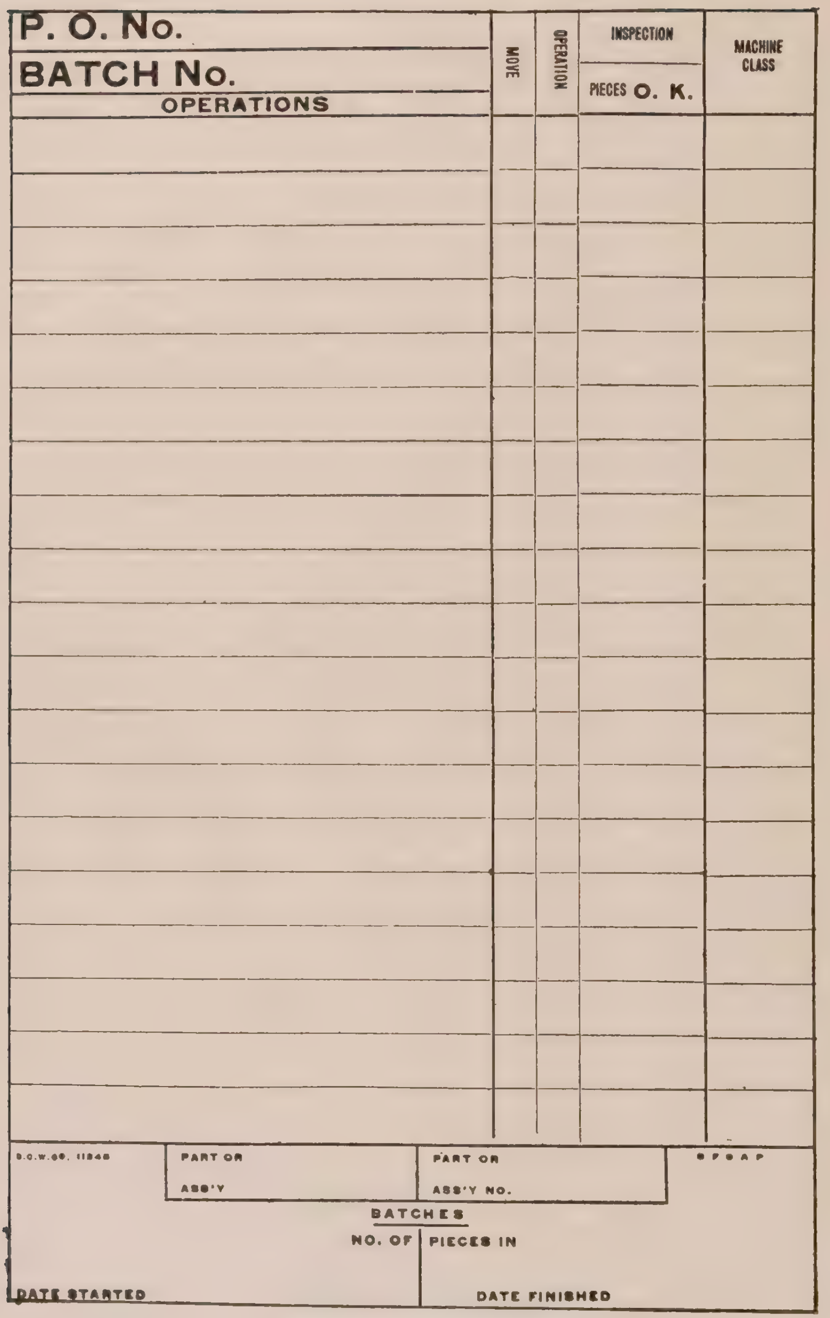
Changes in the sequence may also be made on the basis of instructions received from the schedule clerk. These changes are usually the result of departures from the actual forecasted results. In some cases it is due to failure of the shop to live up to the schedule or to better it, and in other instances it is due to a change in outside conditions, such as cancellation of orders or requests to rush particular orders. Such changes must necessarily be based on a comparison between actual and forecasted accomplishment, and hence it is necessary for a record of what has been done to be prepared from the dispatch returns. This means the keeping of a record of the status of each order as a part of the work of dispatching the work through the factory.

The significance of the dispatch board.—Before going on to an investigation of this record, however, it is desirable to glance at one or two more points in connection with the dispatch board. It should be noted that this board is really a kind of layout of the shop, for on it are shown all the various production centers. The present condition of the shop should always be represented by a card or ticket of some kind on the top set of hooks. If a job is in progress, the inspection and move tickets will serve to identify it and will indicate that the time ticket is in the possession of the worker. If the machine is being set up, the tickets for the job may be covered with a set-up tag to show what operation is in progress. If the machine is not in operation, a card should be put on the top set of hooks indicating the reason, such as, "machine down for repairs," "no material," "no worker," "no job," etc. If this is done, a glance at the board will show the condition of the shop at any particular moment.

The other sets of hooks will also tell much about the shop. The second set, when it is filled with tickets, will show that those production centers are crowded with work, and will usually point out unfailingly the points of immediate congestion. If any readjustment of the shop is to be made, these are the machines which need assistance. The third set of hooks will indicate the production centers which are likely to be congested in the immediate future. When the dispatch board is studied in connection with the schedules, the means are at hand for controlling production to a large extent.

Schedule card.—It has been pointed out that it is necessary to keep a record of the progress of the various orders. This can be quite conveniently done in many cases by means of the card shown in Figure 78. This card is so arranged that the operations in sequence are listed at the left, and columns for all the various steps which are involved in the completion of any operation that produces a change in the form or condition of the material are listed at the right. When a ticket is sent out directing that any of these steps are to be performed, a line is drawn in the column for the operation half across the space on which the operation of the group is described. When the operation is completed, the line across the space is finished. A glance at the card will show in just what condition the order is at any moment.

From these cards reports of the progress of the order may be obtained as frequently as desired. Usually a report once a day will be sufficient for posting work done against work scheduled. To a considerable extent the coördination between the schedules and dispatching must be accomplished by means of personal conferences between the dispatch clerk and schedule clerk. These two must coöperate fully if successful control of production is to be attained.



P. O. No.

BATCH No.

OPERATIONS	MOVE	OPERATION	INSPECTION PIECES O. K.	MACHINE CLASS

[illegible]	PART OR ASS'Y	PART OR ASS'Y NO.	[illegible]

BATCHES

NO. OF | PIECES IN

DATE STARTED

DATE FINISHED

Fig. 78.—Schedule Card.

Unit of scheduling and dispatching.—The unit which is used in scheduling and dispatching the work through the factory is the batch or lot which was discussed briefly in the chapter on routing. The use of this unit for scheduling and dispatching should be more clearly evident in the light of what has been said about dispatching. An order, for example, whose longest operation might take several weeks and the shortest one several days might well require a month or two for completion if the second operation could not be started until after the first one for the entire order was finished. By dividing such an order into a number of lots or batches, each batch may be dispatched in the same way as an independent order. In this way a number of batches of a single order may be in process at one time and the completion of the whole order materially speeded up. Small orders are, of course, treated like single batches of a large order.

Conclusion.—The whole problem of dispatching work through the factory is closely interrelated with the scheduling of production, for one cannot be carried on satisfactorily without the other. They form closely related phases of the production control problem.

References for Additional Reading.

Basset and Heywood, "Production Engineering and Costkeeping," Chapter VIII.

Carpenter, C. U., "Increasing Production, Decreasing Costs," Chapter IV.

Emerson, H., "Twelve Principles of Efficiency," Chapter IX.

Lansburgh, R. H., "Industrial Management," Chapter XLI.

CHAPTER XXVI

THE PRODUCTION, STORAGE, AND ISSUE OF TOOLS

Purpose of this chapter.—To study the relationship of the design, production, storage, and issue of tools to the control of current production.

Classification of tools.—There are many different kinds of tools which may be classified in a number of different ways. From the point of view of their control in relation to production, it is usually convenient to divide them first into three groups: (1) standard tools, to be purchased from outside suppliers, (2) standard tools, to be made within the plant, and (3) special tools.

The first class of tools offers the fewest problems. As they are standard, produced by another company, the concern that uses them has nothing to do with the question of design except to make sure that their form is such as to make them available for the use which they are to have. If they are used only infrequently, it is generally possible to rely on purchases made in the open market, except when business is very active and hence the available supply of tools is low. If they are used regularly and in relatively large quantities, it is desirable to carry a supply continuously on hand and to control that supply by means of a record very similar to that for materials which are carried on the so-called "maximum-minimum" basis.

If the tools are standard—whether from the standpoint of commercial standards or of a particular concern makes no difference—but are made within the plant, they are very much like parts and assemblies which are used in making the finished product, in so far as their control is concerned. This means that the tools must be planned and scheduled in much the same manner as worked material, machines, materials, and workers, scheduled for their production, and their quantity restricted or expanded in consonance with the rate of output of merchandise. In a good many cases, control of this kind of tools is vested in the Planning Department, and a certain section of this department may appropriately be set aside for handling them. In the factory, under such circumstances, there is usually a Tool Manufacturing Department, devoted entirely to the fabrication of tools, which corresponds to the direct manufacturing departments in so far as the making of the product is concerned.

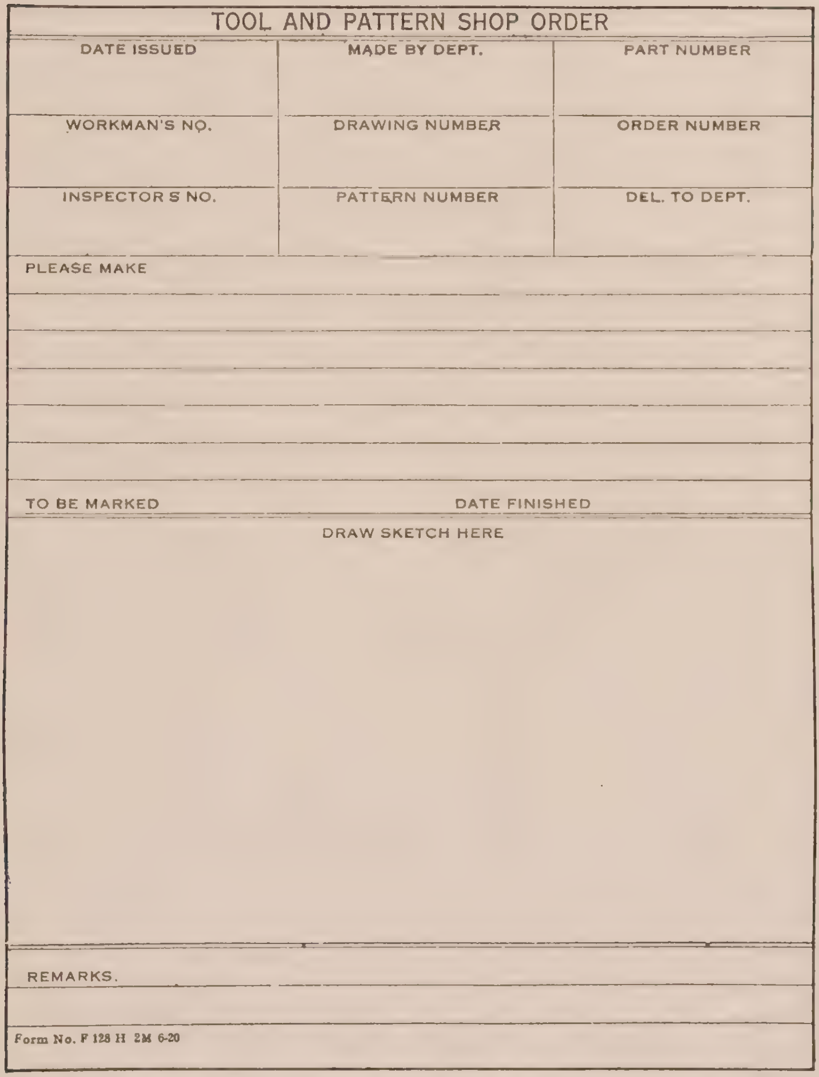
The third class of tools—special tools—is the group which causes the most trouble. It is found, of course, almost exclusively in the jobbing type of industry and forms one of the factors which cannot be forecasted except in very general terms. With standard tools, whether made in the factory or purchased outside, the design can be determined in advance and the tools procured before any orders are received for the product. In the jobbing type of industry, on the other hand, no step in the direction of the design of special tools can be taken before the order for the merchandise is received. Fortunately, it is not always necessary to design special tools even though the order calls for something which the concern itself never made before. In many instances, it is possible to employ standard tools, the change in the product being effected by the way in which the tools are utilized.

The design of tools.—Whether tools are special or standard for the particular company they must be designed and this task should be assigned, under most circumstances, to the Manufacturing Standards Department unless there is a special Tool Designing Department working in close coöperation with it. The reason for the desirability of such an arrangement is seen when the relationship of the design of the tools to the setting of manufacturing standards, especially operation standards, is considered. The difficulty involved in performing many operations can be greatly reduced if the tools are designed, not only with the ultimate object in mind—changing the form of the material to a particular shape—but also the methods to be employed for accomplishing the desired result.

To a considerable extent the design of tools is a technical problem. It necessitates an intimate knowledge of the product and also a thorough understanding of shop processes. A good tool designer must know the characteristics of the material on which the tool is to be employed, the machine of which it is to form an essential part, and the results which are sought from its use. The design of a tool represents a "transfer of thought, skill, and intelligence" and if this transfer is not made, the factory will suffer the consequences as long as the tool is employed. Even though an individual tool is used up rapidly, if others are made to replace it, its effect is as durable as though it were a machine which had been designed. Through its effect on the manufacturing standards the design of the tools influences to a considerable extent the control of production.

The relation of tool production to merchandise production.—In many instances, also, especially in the case of special tools, the actual production of the tools has a bearing on the control of production. It takes time to make tools as well as to design them. The fabrication of a die for use with a punch press is a good example. The metal in which a large part of the work is done is tool steel, very hard and durable, especially if it is used to cut other steel. It must be made in many instances with a high degree of accuracy, for unless it is accurate, it will not do good work, and turn out a satisfactory product. It is often necessary to work to angles, measured to a single degree or even fractions of a degree. To do such work, long training and much experience in working with metals is required. The work itself is likely to progress slowly as it is a costly matter to make a mistake and be obliged to scrap the material and begin again and it is usually even more costly to utilize a poor tool. In many instances, the progress of an order may depend on the tools being produced as scheduled and hence the Planning Department is vitally interested in this matter.

If the concern is using standard tools, or, at least, tools which it uses and produces in large quantities, the problems involved are somewhat different. It is even more essential in this case to make sure that constant supply of tools is maintained, for if, for any reason, tools are not available, all production stops. In the case of the jobbing industry using special tools, it is usually possible to replace an order held up for lack of tools with some other, and though a loss may be incurred and much bother encountered, work is not entirely stopped. In the continuous process factory, on the other hand, lack of tools for any one operation may prevent completely the performance of that and subsequent operations.



TOOL AND PATTERN SHOP ORDER

DATE ISSUED	MADE BY DEPT.	PART NUMBER
WORKMAN'S NO.	DRAWING NUMBER	ORDER NUMBER
INSPECTOR'S NO.	PATTERN NUMBER	DEL. TO DEPT.

PLEASE MAKE

TO BE MARKED

DATE FINISHED

DRAW SKETCH HERE

REMARKS.

Form No. F 128 H 2M 6-20

Fig. 79A.—Tool Order—Obverse.

The control of tool design.—The control of the design and production of tools is usually affected by means of written orders, an illustration of which is shown in Figure 79. The sketch which is referred to is to be made by the engineer who decides on what tool is wanted and, in general, how it is to be designed. On it can be put any suggestions to the tool designer, who has the task of making the detailed design. When such an order goes to the tool-maker it should be accompanied by a blue-print of the tool, except in those cases where the

STOCK CHARGES

DATE	PCS.	ARTICLE	LBS.	OZ.	COST PER 100	

Fig. 79B.—Tool Order—Reverse.

tool is so simple and the tool-maker so skilled that it is unnecessary to make a detailed drawing, the sketch being employed to convey all the needed information.

Such orders should be issued by the Planning Department whenever there is a need for new tools. They should be scheduled both as to the design, and the production of the tools. In the case of the design of the tool, the Manufacturing Standards or Tool Designing Department should be requested to make a definite promise of the time when the design will be completed, and the Planning Department should then follow up this promise to make sure that it is kept. In regard to special tools, the same procedure should normally be followed. For standard tools, produced regularly, a system of control similar to that used in connection with the product is usually desirable. Under such conditions, tools can be scheduled, as are the other factors involved, in the actual fabrication of the product, this schedule being based upon and forming a subdivision of the main production schedule.

The storage and issue of tools.—In the past and even now, in the case of small shops, it is the custom to allow the men to help themselves to any tools they might want and to keep them as•long as they desire. Such a system, or rather, lack of system, is quite incompatible with any real control of production. It is essential for an adequate supply of properly conditioned tools to be at hand and available for use when wanted. This can only be accomplished if the tools are stored in some easily accessible place, ready for issue when needed and returned when no longer needed, or damaged, dulled or used up.

A definite system of tool storage and issue is an essential part of the mechanism of production control in all cases where tools form an appreciable part of the shop equipment. An adequately planned system means less capital tied up in tools, a better and more complete utilization of them, less breakage, loss and stealing, and an increased output due to their better condition. Such a system aids greatly in the scheduling and dispatching of the work through the factory, prevents loss of time and workmen and machines and promotes the maintenance of operation standards.

When tools are not stored in some definite place and are issued only when needed, the tendency is strong for each workman to make a collection of all the tools which he thinks he is ever likely to need, so that he will not later be delayed for lack of them. This is frequently the case with men of unimpeachable honesty who would never think of stealing from the company. They are, however, depriving the company of a large part of the service which it should secure from its tools, and are necessitating an increased tool inventory which is not really needed. Actual stealing of tools also takes place, especially of such small measuring tools as micrometers and gauges of certain kinds which have general appliability. Such tools are valuable, easily slipped in the pocket and can be disposed of without difficulty.

The maintenance of tools.—Tools should never be put away unless they have been re-conditioned. If tools are not ready for use when they are wanted for any purpose, machines stand idle with consequent unearned burden and upset schedules. Any reason, therefore, which keeps tools from being available for use when wanted, whether it is because they are in some workman's locker or have been stolen or are out of condition interferes with the control of production and increases its cost. Tools should be sharpened and conditioned after use before being stored and this task, as a rule, should be taken from the workmen and given either to the man who has charge of the storage of tools or to some one whose particular task is to see to it that they are sharpened.

Tool cribs.—In most cases, tools are stored in special storerooms called "tool cribs," which are located in the shop near the machines in connection with which the tools are to be used. This is especially important in the case of a jobbing concern where it is usually necessary for the men to come to get their own tools. It is less important in the continuous process type of shop where the tools are often delivered at the machines where they are to be used.

Tool storage equipment.—Tool cribs should be equipped with the necessary means of storage, the kind to be chosen depending on the nature of the tools to be stored. Lathe dogs, planer spikes, fastening bolts and devices of various kinds can be tossed in a drawer. Drills must be placed in racks so that they will be protected from damage; milling cutters should be hung on hooks so that their teeth will not touch those of any other cutter; lathe, planer and shaper tools should be placed on shelves so that their points will not be injured, micrometers and gauges ought to have a separate box for each one or each set and then be stored on shelves or in drawers. In the case of master gauges and other especially valuable tools, it may be desirable to store them in a fire-proof vault.

The layout of a tool crib.—The cribs should be arranged for convenience in handling the tools. The basis for such an arrangement should normally be the tool classification, but, as in the case of stores, it is frequently necessary to depart from this classification in certain particulars. Large, heavy tools, such as punch press dies, should be stored on or near the floor; very valuable tools may be kept in a vault, etc. In most cases the equipment will include drawers, bins, racks of various kinds, including sliding and swinging doors on which small tools may be hung and so an economy of space can be effected.

The duties of the tool crib attendant.—The tool cribs should be provided with an attendant who will deliver the tools when they are needed, and take them back when the work for which they were needed is completed. It is often possible for him to sharpen the edged tools which have been dulled through use, but are otherwise in good condition. It is unwise to allow the workmen to sharpen their own tools, as it takes them away from their work and their machine lies idle. A tool grinder in the shop is usually a kind of workman's bulletin board for it serves as a convenient center at which all the shop news is "swapped" while the men are waiting their turn at the wheel. Hence the time of more men than the one who is actually using the grinder is wasted.

The grinding of tools.—In most cases, also, the men do not know how to grind their tools. Much time has been devoted to the determination of the proper shape and angles for cutting tools, both of which vary with the kind of metal in the tool and the material to be cut. It is hardly to be expected, therefore, that the ordinary workman, no matter how experienced and industrious he may be, can select the best angles and then grind his tools to them. His eye may be excellent in judging such matters, but it is not as infallible as a mechanical device for measuring the angles. It is much better, therefore, to equip the tool-crib with a grinder and a tool holder which permits grinding a tool to any predetermined angle, and let the tool crib attendant do the grinding in his spare time. If the tools need more than grinding to recondition them, they should be sent to the Tool Manufacturing Department for repair.

The issue of tools.—In a continuous process type of factory, such as many automobile plants, when tools are used regularly and extensively, a simple way to control the distribution of the tools is to equip each machine, when it is set up and a job is started on it, with enough tools for about a day's work, assuming the normal wear and tear. Twice a day, once in the morning and once in the afternoon, a boy should make the rounds and replace all dull and broken tools with good ones. If a tool is broken it is usually well to have its return checked by the foreman or sub-foreman to note whether the break was due to the carelessness of the worker or the fault of the tool. As long as he turns in a tool even though it is in pieces the worker should have it replaced so that the work will not be delayed.

In the jobbing type of factory, on the other hand, it is usually most satisfactory to have the workman get his own tools. The Planning Department may notify the tool crib attendant in advance, or the workman may bring his instruction card on which the tools needed for the job are listed, or, in some cases, he may present his time ticket and get both tools and instruction card from the attendant. In any event, it is necessary to maintain some kind of record of where the tools are. One way of doing this is to list the tools given out on a tool list and have the man sign it as a receipt. It is then returned to him when he brings back the tools. This method is open to two objections. Both the workman and the tool crib attendant have dirty hands and hence such slips become soiled and grimy and often illegible. Moreover, when a low grade of laborer is employed, he is frequently illiterate and it is found that workers have trouble in signing their names. More often, therefore, either the single check or double check system is used.

Single check system.—In the single check system, each workman is provided with a number of brass checks bearing his number. When he receives any tools, he turns in a check for each tool which is given him. The checks are hung on hooks near the places where the tools are stored in the crib. When he turns in the tools he gets back his checks. In this way every tool should be in its place or be represented by a check, for if the tools are held for repairs, special checks should be put on their hooks. In a small tool crib, especially when each worker withdraws only a few tools at a time, this system works very well for it is easy to locate the position of the tool and it is not very difficult to run over all the checks and find out which ones, if any, a man has. In a large tool crib, however, particularly if the men withdraw a number of tools at one time, this method sometimes proves to be inadequate and the double check system is employed.

Double check system.—The double check system is similar to the single check system in that each workman is provided with checks having his number. In addition, each tool is equipped with a check which hangs on a hook nearby when it is in its place. When a tool is withdrawn the workman's check is hung on the hook near the tool as before, while the check bearing the tool number is hung on a hook below the workman's name and number, all such hooks being grouped together on a board. In this way, a glance at the hook near the tool storage will show who has the tool while the checks on the workman's hook will indicate which tools he has. In one of these ways a record of the whereabouts of each tool should be kept at all times.

Conclusion.—Tools, when they form an essential part of the operating machinery, are one of the most important factors in the control of production. Their design forms an integral part of the setting of manufacturing standards, but the control of their production is one of the tasks of the Planning Department and their adequate storage and proper issue is a task which is often assigned to the plant engineer. In whatever way the details of these problems are worked out, however, satisfactory plant operation cannot be attained unless they are solved.

References for Additional Reading.

Basset and Heywood, "Production Engineering and Cost Keeping," Chapter V.

Jones, F. D., "Modern Tool Making Methods," Chapters III, VI, VII.

Jones and Hammond, "Shop Management and Systems," Chapters III, IV, VII-XI.

Jordan and Harris, "Cost Accounting," Chapter XXVIII.

Thompson, C. B., "Scientific Management," page 434-451.

CHAPTER XXVII

INSPECTING MATERIALS AND SALVAGING DAMAGED GOODS

Purposes of this chapter.—

1. To study the problem of inspecting materials.
2. To outline methods for dealing with this problem.
3. To survey the problem of disposing of damaged materials.
4. To consider possible ways of handling this problem.

Inspection in the factory is one of the means of production control. There are commonly two kinds of inspection—(1) that in which the quality of the material is verified, and (2) that involved in ascertaining the quantity of output. Both are necessary in the administration of production. Not only is inspection an instrument of control, by eliminating spoiled parts, checking up operations to make sure that their results are satisfactory from the start, indicating workers who need instruction and those who are lazy and shiftless, and in this way aiding in the dispatch of the work through the factory and the maintenance of schedules, but it is also productive of positive benefits in various ways. Not infrequently improvements are made in the selection of the material, the design of the product, the method of performing the operation, etc., as the result of the discoveries made while inspecting the goods. Inspection, therefore, should not be thought of as a negative process for the elimination from the regular course of production of those materials and parts which are not up to the quality standards that have been set, and the measurement of the amount of output, but also as a means of constructive work in the control of production. Inspection is a measuring device and, as in the case of all measuring operations, it is possible to accumulate much data which is often of importance beyond that of the information obtained concerning individual items.

The significance of inspection.—There are few factories where inspection of one kind or another is not employed to a greater or less extent. Unfortunately, the real importance of this activity has only rarely been appreciated, and hence it seldom receives the consideration which is due it. Inspection is too often looked upon as causing needless expense, and, as it is not directly productive, the tendency is to get along with as little inspection as possible. Proper and adequate inspection in the measure required by the conditions of the factory is a very real economy, not only in the ways suggested in the preceding paragraph, but in a direct saving of losses which would otherwise be incurred. If parts are allowed to pass from operation to operation after they have been spoiled at some operation and hence are rejected when they come to be assembled, all the labor and earned burden which has been charged to them as well as the value of the raw material of which they are composed, is thrown away. If they had been eliminated after the operation in which they were spoiled, all the subsequent labor and burden would have been saved. In addition, it is often possible, if only a little damage has been done to the material, to repair it if the proper steps are taken as soon as the mistake is made. If other operations are performed on this article, all chance of repair is almost invariably gone.

The basis of quality inspection.—The fundamental basis for quality inspection—which is usually the more important because it is the more difficult of the two—is the manufacturing standards for material which have been established. These standards give consideration, not only to the exact specifications of the thing wanted, but also to the economic limitations placed upon that exact specification by the impossibility of doing more than approximate the exact specification in current practice. Frequently, in practice, the major portion of the inspection problem lies in the difficulties encountered in the setting of these standards. If the factory in question is provided with a Manufacturing Standards Department, which is equipped to handle a problem of this kind and to guide the Engineering or Designing Department in the setting of tolerances for the exact standards of its theoretical design, then this part of the problem is settled and only the real inspection problem—the measuring of the actual material against the working standard for it—remains.

The comparison of the actual with the standard.—This second part of the problem is often difficult enough to test thoroughly the resources of a capable engineer. The means must be provided for measuring the materials—means which are at least as accurate in their application as is the working standard which has been established—and these means must be provided at a cost which permits their acquisition, and must be usable at an expense which is not prohibitive. Take, for example, the parts of a precision measuring instrument, such an instrument as that used in dry goods stores for measuring all kinds of cloth. The completed instrument must meet certain government standards of accuracy which are very rigid and exacting. In order that the finished machine may successfully pass these final tests, it is essential for most of the parts to be made with a high degree of accuracy. In some instances, these parts must be accurate to within 1/10000 (.0001) of an inch or even 5/100000 (.00005) of an inch. It is relatively difficult to produce an instrument which will measure with such accuracy, and it is also difficult to use such an instrument, for it must be remembered that heat causes metals to expand and even the heat of the hand will bring about a sufficient change to make very accurate measurement impossible.

It should not be thought that such problems are isolated and exceptional. All good watches have most of their parts made to at least this degree of accuracy; many of the automobile parts and scientific apparatus of various kinds are other instances of articles whose dimensions must be made to such a degree of accuracy. Dimensional measurements are not the only ones which present this type of problem. Electrical apparatus of many different varieties requires the measurement of electrical qualities with just the same degree of accuracy. Coils, used in the ignition systems of automobiles and in electrical control devices of many kinds, are another illustration, for their resistances must often be held within very close limits.

The extent and methods of inspection.—While a great many materials and parts must be subjected to such close scrutiny as has been suggested in the preceding paragraph, there are many cases where there is no necessity for having such close tolerances as a part of the manufacturing standards. In fact, frequently, it is unnecessary to inspect every part after every operation. It is quite reasonable in many instances to inspect after two or three operations, and, for small and inexpensive parts, only after the part has been completed. Under certain conditions it is possible to have the worker inspect the work of the preceding operation and throw out those parts which are not satisfactory. This plan is only possible, usually, when the subsequent operation cannot be performed unless the preceding one has been satisfactorily completed.

It is also possible to inspect the product sufficiently by a sampling process. By this method, samples of the material are inspected and, if they are passable, the whole lot is accepted, but if more than a certain percentage of the samples is rejected, the whole lot is either rejected or each unit thereof is inspected. It is essential, of course, when following this method to choose the samples from all parts of the lot in order to test thoroughly the entire lot.

Kinds of materials to be inspected.—There are two different kinds of material to be inspected. They are the same two groups that were described in the discussion of the control of material—stores and worked material. The actual tests to be applied are the same whenever the material is the same, but the organization of the two kinds of inspection is somewhat different.

Stores material is ordinarily inspected in the Receiving Department. In some cases, the inspection is made a part of the receiving operation, but in other cases it is a separate operation carried on by inspectors. It is quite essential, of course, that no unsatisfactory material be accepted and paid for. Such material is a direct loss and often results in indirect losses due to trouble which it causes in the shops. It should also be noted that, in some cases, incoming material is inspected by the purchaser before it is shipped by the vendor. This method has distinct advantages in saving expense for both purchaser and vendor. Its possibilities are limited to large concerns who purchase in sufficient quantities from one vendor to make it worth while to keep an inspector constantly on the job at the vendor's plant.

The inspection of goods-in-process.—It has already been pointed out that it is frequently desirable to inspect the material after the first few pieces have been turned out from any operation and the reasons therefor have been indicated. The rest of the inspection of goods-in-process, to whatever extent it is carried, is done after the operation is completed. In general, there are two different ways of organizing this second or final inspection. One way is to have the inspectors come to the work and pass upon it before it is moved to the next operation. This method works most satisfactorily when the quality inspection is not very exacting and where the principal inspection is to ascertain the quantity which has been produced.

The other method is to have the materials moved to an inspection booth or department and passed upon there. This procedure is ordinarily necessary whenever any special equipment is necessary for making the inspection, or when laboratory tests of one kind or another are required. In most cases it is not easy to install such equipment in the operating departments. There is always the likelihood of damage to delicate measuring instruments from accidental blows, dust, etc. The segregation of the inspection in this fashion also facilitates the work of the inspectors by removing outside distractions, so permitting greater concentration on their tasks.

Quantity inspection.—There are two principal reasons for the importance of quantity inspection. In the first place, it is necessary to keep track of the quantities of material which pass from operation to operation, for there are few cases where one or two units are not spoiled and removed, temporarily or permanently, from the flow of production. Provision is usually made for this by starting more units at the first operation than are required in order to provide for this dropping out along the way. If, however, the quantity is reduced below that of the finished product required, it becomes necessary to make up the deficiency in some way, usually by ordering more of the product. Information in regard to quantities completed at regular intervals in the course of production is necessary, therefore, to furnish an explanation of the departure of actual from scheduled results, and to provide information on the basis of which changes in the plans and schedules may be made.

Whenever an incentive method of wage payment is employed a quantity inspection, in addition to a quality inspection, is usually necessary after each operation in order to furnish a basis for the payment of the bonus or premium. It is ordinarily necessary under such circumstances to have a quality inspection also, for it is seldom desirable to pay a worker for work which is not satisfactory, if the spoilage is his fault, no matter how large a quantity he may turn out.

The staff of inspectors.—In most cases inspection is carried on by means of a staff of employees of the company. In some cases, however, it is desirable to have recourse to outside assistance. This is especially true in the case of the necessity for laboratory tests which are essential, but which are so few in number as to make the maintenance of a laboratory a prohibitive expense. Even large concerns make use of these facilities to check the work of their own inspectors and laboratory assistants.

The inspection should be in the hands of a staff of inspectors organized into an Inspection Department. It is not necessary that this department be physically located in any one place. It is possible that the inspectors will be scattered all over the plant from the Receiving Department to the final processing department and even in some cases in the Shipping Department to inspect the packing of the goods in order to make sure that they are as well protected as possible against breakage in transit. These various groups of inspectors should be organized under foremen and all of them should be placed in turn under a chief inspector.

The place of the Inspection Department in the organization.—The responsibility of the chief, and thus, indirectly, of all the inspectors, is a much debated question. There are some who would place the chief inspector under the superintendent, or even do away with the chief inspector entirely and make the inspectors directly responsible to the foremen in whose departments they are working. This arrangement would bring the inspection of the product immediately under the control of those who are primarily interested in getting out production. This generally results in work being passed, which should have been rejected, to the detriment of production as well as to that of the finished merchandise.

There are others who would make the chief inspector directly responsible to the general manager, thus taking the control of inspection away from any direct contact with the control of production as a whole or the actual fabrication of the product. The trouble with such an arrangement as this is that, in most cases, the separation between inspection and actual production is too complete to make adequate coördination easy, and, in addition, the general manager is usually so fully occupied with more general and important problems that inspection does not receive the proper amount of supervision.

What is wanted is a place in the organization where it will be possible to establish proper and adequate coördination between inspection, planning, scheduling, and dispatching and the actual work on the product, and at the same time relieve the inspectors from any uncomfortable pressure to pass goods which do not come up to the standards that have been set up. In general, therefore, it is usually best to make the chief inspector responsible to the factory manager or whoever else may be the actual and titular head of the manufacturing operations as a whole. Such an executive has the responsibility of making all the manufacturing functions run smoothly and, at the same time, he is sufficiently far removed from immediate contact with the detailed operation of the direct manufacturing departments that he should be able to maintain a judicial attitude in regard to them.

The disposal of rejected materials.—A problem arises in regard to the disposal of the materials which are rejected. In the case of purchased materials, one possibility is to return them to the vendor. Usually they should not be shipped to him unless he wishes them, for in some instances they may not be worth shipment. Broken bottles which were purchased with the expectation of using them as containers are not of any value to the vendor and shipping them back to him merely increases his loss. However, where the error lies in having sent the wrong size, for example, the goods may be worth full value to any one who wishes that size. Even under such circumstances it is well to await shipping instructions, for it is possible that the vendor may wish to have them shipped to some other customer instead of having them returned to him. They may be billed back to him, generally, without awaiting any instructions in regard to shipment.

The treatment of damaged stores.—Under some circumstances the goods may be retained. If the purchasing company is very short of materials it may prefer to keep them and either use them as they are, or repair them before using rather than go without them. The vendor may, perhaps, be willing to make an adjustment and so it may be worth while for the purchasing concern to keep them and use them for "seconds," or repair them, even though it may have no pressing need for them.

The salvage of spoiled worked material.—In the case of material which has been worked upon, the possibilities for rejected material are rather different. In the first place, the material may be thrown away as worthless or even burned under the boilers as is sometimes done in wood-working factories. It may be scrapped or sold for whatever can be obtained for it in the condition in which it is. These possibilities are the least desirable as they result in a heavy loss in value in most cases, though simple copper parts may have a value as scrap which is a large percentage of the value of copper in any of its standard forms. Selling as scrap means a small saving from a total loss, but most of the value of the raw material labor and earned burden is thrown away.

At the opposite extreme is the possibility of repairing the damaged articles so that they can be used for their original purpose. In many cases, it is possible to put the part back into the regular course of production after some minor alteration has been made. If the part is too large, for example, it may be reduced to the size it should have been after the operation in question. If the part is too small, it may, perhaps, be made still smaller and so meet the requirements of a smaller sized part. In some cases, the material may be spoiled for use as first grade but still be usable as "seconds" and so a large part of its value may be saved.

The reinspection of unsatisfactory goods.—A very important practical problem is encountered when a decision must be taken in regard to particular damaged goods. Shall they be scrapped, repaired, treated as "seconds" or disposed of in some other way? The inspectors, in rejecting any material, indicate that it is not up to the standards which have been set. In their capacity as inspectors this is as far as they go. It is not their task to decide what shall be done with the rejects.

Hence, after material has been turned down, it is usually necessary to reinspect to discover the extent of the damage and to decide what shall be done with it. This task is much more difficult than making the first inspection when little is left to the discretion of the inspector. The article either is or is not up to the standard; it is either accepted or rejected. In the reinspection it is necessary to decide what can be done and then what is *best to be done*—which is quite another proposition. To know what can be done, it is essential for the person who is to make the decision to have an extensive technical training of a practical kind. To choose the best course to be followed in any particular case requires more than this, however. It necessitates an acquaintance with the costs of various kinds of repairs, for, unless the person who is to reinspect is equipped with this kind of information, he can hardly know whether the loss will be less to pay more for additional work or to scrap the article and get all that is possible out of it as scrap.

The control of salvage operations.—The position of salvage inspector is an important one, for it holds the possibility of saving the company very appreciable sums in the course of a year. It is a very good task for old employees whose age prevents them from standing the strain of some regular job in the shops, but whose experience fits them admirably for just this kind of task. During the course of a long and varied experience in the different departments they often acquire many bits of information and learn many tricks of the trade which are especially helpful in dealing with just this kind of problem.

It is desirable that the person who decides whether the material is worth salvaging should also map out the route which the work should follow. There is no need of having a third inspection to decide how the material shall be mended. The route to be followed should be entered on a large tag and attached to the material.

The organization of the salvage work.—In general, there are two different places in which damaged materials may be repaired, (1) in the regular manufacturing departments, and (2) in a special Salvage Department. The use of the Salvage Department is desirable when the repair operations differ from those of the regular course of manufacture. The damaged material may be either completely finished in the Salvage Department or it may be repaired so that it can again be put back into the regular flow of production. The completion of the salvage work in the Salvage Department is desirable when there are only a few pieces to be reclaimed, and especially when it would be likely to be inconvenient to send them to the regular manufacturing departments because of the completion there of the order on which they were being produced. On the other hand, if there are many units to be salvaged and particularly if, after being repaired, it is possible to start at some operation in the regular sequence for the order, it is often well to send them back as a part of a batch already in process or as a special batch. If there is so little salvage work to be done that it is not worth while to organize a Salvage Department, all the work of reclamation can be done in the regular shops. Such a procedure is likely to interfere seriously with the shop schedules and the dispatching of the work, if there is much of it. Wherever salvaging is done in the regular shops or special batches of salvaged parts are created, it is necessary to schedule and dispatch all of this work in the same way that the other work going through the shops is dispatched.

Conclusion.—The whole problem of the salvaging of damaged material is one of the most important questions with which the factory manager is confronted. It is one of those exceptions, one of those departures from the regular routine of production procedure which always requires more than its proportionate share of attention.

References for Additional Reading.

Carpenter, C. U., "Increasing Production, Decreasing Losts," Chapter XII.

Dinsmore, J. C., "Purchasing Principles and Practices," Chapter XXVIII.

Lansburgh, R. H., "Industrial Management," Chapter XVI.

Radford, G. S., "The Control of Quality in Manufacturing," Chapters III-XII.

CHAPTER XXVIII

STOCKING AND SHIPPING THE FINISHED PRODUCT

Purposes of this chapter.—

1. To investigate the problem of stocking and shipping merchandise.
2. To study methods for the control of these activities.

After the last step in the manufacturing process has been completed, there still remains the task of starting the goods to the customer. In general, it will be found that merchandise, in so far as its control at this point is concerned, may be divided into two main groups: (1) goods which are shipped as soon as completed, and (2) goods which are manufactured for stock, and shipped from stock when needed. Roughly, these two classes correspond to the jobbing and continuous process types of industry. It will, however, be found frequently that the continuous process type of factory may ship goods as soon as they are completed. This is often the case in the smaller textile mills, which make a limited variety of cloths to order only, but which operate continuously on an order after it has been received and ship the product as rapidly as a convenient shipping quantity is completed. Of course, many concerns manufacture both kinds of goods and hence have to face the problems raised by both.

The stocking of the finished product.—In many respects the problems encountered in stocking the finished product are quite similar to those met in storing raw materials (raw from the point of view of the factory using them). It is essential to have the stock located in a convenient place in relation to the assembling or finishing departments. In general, this means somewhere on the first floor of the building so that gravity can be employed to move at least a part of the material to the place where it is to be held until shipped. In some cases, however, a different arrangement promotes the same results. An envelope factory, for example, had its storeroom on the first floor (there was no basement) and moved the material from there to the printing presses also on the first floor, or directly to the fourth floor in the case of envelopes without return addresses, to be cut. Printed envelopes were also moved to the fourth floor. After cutting, the envelopes were folded and sealed on the fourth and third floors, moved by gravity to the stock-room on the second floor or directly to the Shipping Department, also on the second floor, where they were boxed for shipment and shot down a gravity chute to the shipping platform. In this case, full use was made of gravity and the Stock and Shipping Department was located in its proper relation to the means of transportation of outgoing shipments, which is the other prime consideration in the location of this department.

The layout and equipment of the stock room.—In addition, the stock room must be fitted with the necessary storage equipment of various kinds for holding the merchandise until it is shipped. In general, this equipment is very much like that used in the Stores Department. There is more likelihood of having packaged goods to handle, and greater care must be exercised in putting away and taking out the merchandise in order not to damage it.

It is also especially necessary not to allow old goods to accumulate, for they may not prove to be satisfactory later when shipped out. It must be remembered in this connection that the harm done to the reputation of the company and its product is far more important than any loss of a few units. All this means that greater convenience for the handling of the goods in the stock room must be provided than in the storeroom, even at the expense of a certain lack of economy of space. For small parts, shelves replace bins to a large extent because most small parts are packaged as the last step in the manufacturing process. Bins are often necessary, however, and, in addition, racks, frames, and other containers are frequently needed.

The measurement of goods for shipment.—The problem of the measurement of the goods for issue from the stock room for shipment is usually much less complicated because of the fact that the merchandise is commonly completed in the units in which it is to be shipped. There are very few manufacturing concerns, even those which sell in small lots directly to retailers, that are obliged to subdivide the units in which the merchandise is put up in order to prepare it for shipment. Most manufacturing companies, which fabricate goods for the ultimate consumer, market them through wholesalers and jobbers, and hence the size of the shipments which they make are usually relatively large.

The packing of goods for shipment.—Whether the goods are shipped from stock or are shipped as soon as completed, it is necessary to pack the goods for shipment. This is one of the most important problems which is encountered in connection with the finished product. If the goods are not adequately protected in transit and reach their destination in a damaged condition, they are not likely to be producers of profits; but on the other hand they probably will result in losses, both direct and indirect. It is also essential to give some little consideration to the cost of packing, as with the increasing cost of lumber, boxes of all kinds have risen considerably in price. In addition, the use of a large amount of wood increases the weight of the shipment, and as freight is charged on the basis of weight, in so far as domestic shipments are concerned, this is also an important point. A slight increase in weight and freight charges, as well as in the cost of materials, is usually not to be offset, however, against the importance of getting the goods to the customer in good condition.

The improvement of containers.—Research and experimental work has been carried on in recent years in order to improve the types of containers which are used for various purposes. Different kinds of boxes are packed as for shipment and then placed in a revolving drum equipped with cleats at the sides. A few minutes or hours in this drum will give the package as much shaking up and knocking around as it would receive in the course of a journey of many miles. In this way, the types of breaks are discovered and steps can then be taken to reduce or eliminate their possibility. Boxes are also tried in material testing machines to see what stresses they will resist in different positions. As a result of these tests and experiments great improvements have been made in the structural details and the kind of wood used in making wooden boxes.

Not only have many developments been brought about in the construction of wooden packing cases, but substitutes of one kind or another have been receiving attention in recent years. Pasteboard boxes have been coming into favor because they can be made from strawboard and other stock which does not call for large quantities of wood. When made of corrugated board and properly braced, they form an excellent substitute for wooden boxes and, in addition, have the advantage of lightness in weight. They often give surprisingly good service under severe conditions.

Boxes of one kind or another are needed for small parts of various kinds. Many large units do not need such protection. Castings of large size can have identification marks painted on them and be loaded on cars without any packing, and many other items can be thought of in this class, though they are few as compared with the wide variety of merchandise shipped.

The packing of large sized units.—Large units, such as complete marine engine assemblies, large machine tools, viz., pieces of farm machinery, etc., represent another phase of the packing problem. In most cases it is necessary to knock down the units to a greater or less extent and then build the containers around the principal group of parts which remain together. It is essential for all the parts to be packed so that none can become loose and either be damaged or do damage to the remainder of the unit in transit. It is also extremely important that none of the parts which have been dismantled shall be forgotten. If possible, they should be packed in the same container as the principal part of the machine, but if this is not feasible, they should be packed separately in a single additional container, and every effort should be made to have the two packages arrive at their destination at the same time. Nothing is more discouraging to a purchaser than to have only a part of his shipment arrive and be obliged to wait for the rest of it to show up before being able to avail himself of his purchase.

Preparation of shipments for export.—The preparation of shipments for the export trade presents many problems which are radically different from those involved in making domestic shipments. As most of our foreign trade is carried on by water, it is essential to pack for transportation by steam-ship instead of by rail. This involves a number of points which deserve particular consideration. The kind of handling in transit which goods receive is much more severe in the cases of water carriers than it is on land. Hence the container must be very much stronger and more rugged than that required for domestic commerce. Many goods need to be thoroughly protected against dampness and moisture, and the problem presented is often a serious one which can only be solved in some cases by using a lead lining in the box, by heavily coating metal parts with grease, and wrapping textiles, etc., with oil cloth. In some parts of the world, shipments are likely to be attacked by vermin or rodents and the goods must be protected against such dangers.

All this means that the weight of the packed merchandise is likely to be much heavier in the case of foreign shipments than in the case of goods being sent to some part of this country.

In one way this does not make much difference, for ocean freight charges are reckoned on a basis of cubic space occupied rather than by weight. This means, of course, that every effort must be made to reduce to a minimum the amount of space occupied by the package. To accomplish this, assembled units are often shipped, almost completely knocked down.

If shipments are being made to relatively undeveloped countries, another problem is encountered—the package must not weigh more than a convenient load for a mule, or whatever other pack animal is employed in these regions. It should be remembered in this connection that to be able to pack a mule properly it is necessary to put equal weights on both sides of his back. Evidently the problems which are involved in packing for the foreign trade are diverse, and in some cases their solutions lead to diametrically opposite conclusions. Adequate packing for foreign shipment is a subject which deserves a special and extended consideration which is quite beyond the scope of this book. It is enough here to call attention to the existence of the problem and to suggest its scope.

The organization of the finished stock and shipping department.—The solution of the problem of control of the finished product while it is in stock and as it is being shipped depends to a considerable extent on the place in the organization of the Finished Stock and Shipping Department or departments, if these activities are divided, as is frequently the case. In general there are two possibilities which are open to a manufacturing concern. One of these is to treat this department as a part of the manufacturing group of functions, and the other is to group it with the marketing or distribution departments.

If the goods are shipped wholly or in part as soon as they are completed, as is usually the case in the jobbing type of industry or any concern where a part of the whole work is on a jobbing basis, it is usually wiser to follow the first plan. The manufacturing processes are not really completed under such circumstances until the product is boxed and loaded. On the other hand, it is quite logical and frequently most desirable when goods are shipped from stock only to consider that fabrication has stopped and marketing has begun as soon as the merchandise is delivered to the stock room. This point of view is especially applicable when the stock room is in a separate building or warehouse, and hence is physically set off from the factory.

In the first case the control of the goods is continued as an integral part of the control of the manufacturing order which calls for their production until they are actually checked out. The entries on the schedule card shown in Figure 71, for example, may be planned so as to provide a record of the goods until they pass into the possession of the common carrier. The last step in production would then be the delivery of the merchandise to the Shipping Department and the final return of the merchandise received slip would mark the completion of the order.

If the control of the finished stock were to come under the supervision of the man in charge of marketing, the receipt of the Finished Stock Department would mark the close of the manufacturing order. In the cases where a part of the merchandise is made to order and a part shipped from stock, the record of the finished merchandise should be kept in the Planning Department on forms similar in their general design to the balance of worked material cards. Such records would tell at once the status of the stock and would provide a means for reserving for shipment those units which are in stock but which must be held until the "to order" part of the shipping order has been completed.

Conclusion.—With this brief study of the problem of the control of the finished product, the problem of the control of current production in the typical manufacturing concern has been outlined from the time when the master schedule first furnished an approximation of the probable quantity of output to be required in a given period, until the finished merchandise is put in the hands of a common carrier. Every manufacturing business has the general cycle of operations to perform by means of methods which vary according to the needs of the particular company, but all of which should be developed in a scientific fashion.

Reference for Additional Reading.

Huestis, B. L., "Shipping Containers" (entire book).

CHAPTER XXIX

RECORDS AND THEIR VISUALIZATION

Purposes of this chapter.—

1. To outline the function and scope of the records used in the control of production.
2. To consider briefly some of the principal records for control of production needed and their interrelations.
3. To survey some of the methods which may be employed for visualizing records.

It is important to decide what records are necessary for the control of a business, and this is a question which can be answered only after an extensive analysis of the needs of information has been made. It is quite possible to record a great many facts about the operation of a business which may be very interesting, but which are not of any real significance in its control, at least from the point of view of the executives.

The basis for the selection of needed records.—To a considerable extent the variety and detail of records depends upon (1) the nature of the business, and (2) the type of executive who is in control. The concern with the relatively simple control problems can function effectively with the help of only a few records, while the company with the complex control questions needs far more detailed data with which to work. In so far as production is concerned, the continuous process type of plant falls in the first class and the jobbing type in the second class. This is the reason why a large concern employing hundreds and, perhaps, thousands of men may require only a few records, reduce the Planning Department to a few clerks in the superintendent's or factory manager's office, and still maintain efficient and effective control of production, while a plant employing only a few hundred men may require a Planning Department of fifteen or twenty workers. The complexity of the activities to be controlled decides the extent to which detailed records must be kept.

The type of executive who is to use the records is also an important determining factor. There are those executives who think largely in terms of written statements, tables of figures and graphic charts, and who feel that they cannot make a wise decision unless they are well fortified with a knowledge of the facts, duly organized to meet their particular problems. Such executives are equipped to use a variety of records, and often the impersonal control exercised in this fashion is highly effective. To prepare the summary reports in the form in which they are accustomed to use their records of completed operations, a large number of detailed records must be gathered and many sub-orders issued, and hence the whole system of record keeping is enlarged and rendered more detailed in order to accomplish the tasks placed upon it.

On the other hand, there are executives who cannot use reports but must go out and "see" what is going on, especially in the case of the factory. These executives possess an almost uncanny ability to get at the essentials of any situation from observation and discussion with their associates and assistants. Under such circumstances it is often possible to get along with fewer records than would be necessary with the other type of executive.

In actual practice, also, it will be found that records which at first seem to be necessary, can later be eliminated or combined with others. One reason for this is that experience shows ways in which records can be simplified and still give the same information contained in the original records. In addition, much of the data which, at first, was thought to be essential to the adequate control of the business, either because it was never needed or because sufficient knowledge concerning the facts has been recorded, makes a further accumulation of data unnecessary.

The decision as to the number and variety of records which are to be used depends, therefore, on the need for information. Whether a particular record shall be maintained or not is largely a matter of expediency and is hardly ever a matter of principle. The system of orders and reports, in so far as they make up a part of the system of records of the business as a whole, is subject to this rule.

Records usually required for the control of production.—A number of records are ordinarily required in the control of production, such as the production schedule, the equipment schedule, the route cards or charts, standard practice instructions, instruction cards, material specifications, balance of stores and balance of worked material cards, time tickets, inspection tickets, move tickets, material issues, etc.

Idle time reports.—In addition to these, certain other records are frequently required for the adequate control of production. One of the most important records of past performance which may be employed as a basis for future plans is a report of the idleness of equipment. Such a report should include a record of all the time in which any machine is not actually engaged productively for any reason. Causes like machine down for repairs, idle for lack of material, idle for lack of worker, no work available, tools not ready, and other reasons of the same general nature have especial significance to the production and factory managers. When compared with the equipment schedule, the record of idleness gives much information in regard to the efficiency of machine operation and the effectiveness of control.

Spoilage reports.—A material spoilage report is one easily compiled from the inspection reports. It should show the quantities of material spoiled, at what machine the damage occurred and what the causes of the spoilage was. It is of vital importance to know whether the spoilage was due to the discovery of hidden defects, the carelessness of the workman, newness to the work or inadequate training on his part, machine trouble, tool trouble, or unsatisfactory material at the beginning of the process. Once the cause of the difficulty is found, it is usually possible to find some remedy.

Idle man hours.—A report on the idleness of the workers is another one of the same series of reports. Machine breakdowns, lack of work, unsatisfactory material, poor tools, lack of instructions, these and many other causes may be found to be the reason why workers are idle from time to time through no fault of their own.

The "exception" rule.—In connection with the preparation of these and other reports it should be pointed out that the higher executives are peculiarly interested in all those items which are exceptions to the general run. They often wish to receive full and comprehensive reports in order to be able to assure themselves that conditions are normal or that they are changing in the sense in which they were forecasted. As long as plans are being worked out as desired it is not necessary for them to give the detailed problems their personal attention. It is when exceptions occur and the plans which have been laid in advance are not realized that the higher executives should take a hand in the control of the situation. Hence, reports of the kind which have just been described are of especial value in the control of the business.

Availability of reports.—The records necessary for many manufacturing concerns are varied and important, and it is essential that they be properly kept and readily available. In part, availability lies in properly and systematically maintaining the records, and, in part, in their adequate presentation. One of the ways in which records may be made usable by the executives and their assistants who have occasion to obtain information from them is to visualize them. In some cases, this visualization involves reducing tables of figures to chart form, and in many instances other graphic means are employed to visualize essentials facts and their relations. Many illustrations have been given in the course of the preceding chapters, but it is worth while to call attention to this particular phase of their utility and to add some further examples.

Organization chart.—The satisfactory control of any phase of a business depends on that business being properly organized. This is especially true in regard to the manufacturing activities which are usually by far the most numerous and which have the most complicated relationships of any of the major functions of a manufacturing concern. It should be recalled that emphasis was laid on the importance of an organization chart (see Figure 5). This chart is one of the most valuable (if not *the* most valuable) records which a business possesses, and the aid which its proper visualization can bring to the control of the business permits each person who holds an executive position to see how his work is related to that of other executives. Only secondary to the main organization chart are those supplementary charts which show in greater detail the same fundamental relationships presented on the principal chart.

In addition to the lines of authority and responsibility which are the basis for the organization of a company are those many other relationships, a knowledge of which on the part of the personnel of the enterprise is essential to its satisfactory functioning. Such lines as those representing routine transfers of information necessary to the control of production, for example, and those for orders and reports are good illustrations of the kind of thing meant. These relationships can be well represented by means of a chart (see Figure 6) which serves to visualize many different connections that would otherwise be hard to grasp.

Another chart which is often very helpful is one that shows the course of the order from the time when it is sent out by the vendor until the time that completed goods are delivered to him. In many cases, it is a failure to grasp these connections which prevents an employee from performing his tasks easily and satisfactorily. A typewritten itinerary, while often giving more ample detail than a chart, is far harder to grasp and hence much less useful in promoting effective control of the business.

Visualized specifications of materials.—Records of the design and specifications of the product and its components have long been made in visualized form for drawings, and the blue-prints which are prepared are one of the earliest forms of visualized record which was used in factories. Such drawings range all the way from sketches to comprehensive assemble drawings which record the various details that enter into the composition of the completed article and of their relation to each other. In fact, so dependent have factories become on this type of visualized record, wherever there is occasion for their use, that if blue-prints were not available, it would be almost impossible to continue operations without them.

Equipment records and plant layout.—While in most instances the essential record of machinery and equipment is represented by the plant register, there are some cases where the record needs also to be visualized by means of drawings. This is usually true in the case of tools where it is necessary to have a drawing of some kind of each tool which cannot, like drills, for example, be specified by means of a catalogue number or other single specifications in writing. All specials almost certainly fall in that class.

The adequate and appropriate layout of the plant is one of the greatest aids to the control of production. The record of the plant layout is almost certain to be visualized in one form or another (see Figures 32, 34, 35). Such charts are especially helpful in the routing of the work through a jobbing type of factory, for they permit the engineer who is doing the routing to see at a glance the course through the factory which he is mapping out for the order in hand.

When manufacturing standards are considered it is evident that visualized records are often very useful. This is particularly true in the case of the routing of an order through a jobbing factory. The route chart illustrated in Figure 56 is a good example of how the route of an order may be recorded in such a way that the entire path which the product is to travel may be followed, showing each operation in its proper relation to every other operation. The relative length of time which it takes to perform each operation on a single unit can be shown by the length of the lines.

Operation standards.—The specification of materials and products in a visualized form has already been pointed out. It should also be noted that the recording of the operation standards often employs visual media in the form of sketches, drawings, and photographs. It is being appreciated more and more that pictorial means of showing how an operation should be performed is often the best way of recording the operation when it is to serve as a basis for the instruction of the workers, some of whom are often more or less illiterate.

The control of current production.—It is in connection with the control of current production, however, that visualized records have the most important part to play. The master schedule on which the control of production depends is often susceptible in one form or another to graphic representation. Figure 80 shows how the balance between sales and production may be visualized and also how a record of accomplishment of both may be plotted against the line indicating the plans. Such a chart has especial value from the point of view of production, because it permits a constant measurement of accomplishment against plans and of sales against production. In many cases this latter comparison is quite as valuable as an aid to the control of production as the comparison between schedules and accomplishment, for it allows the early modification of production schedules to meet any unexpected fluctuations in the sales. The same kind of chart may be prepared to show the status of various lines of product as compared with the plans made for them.

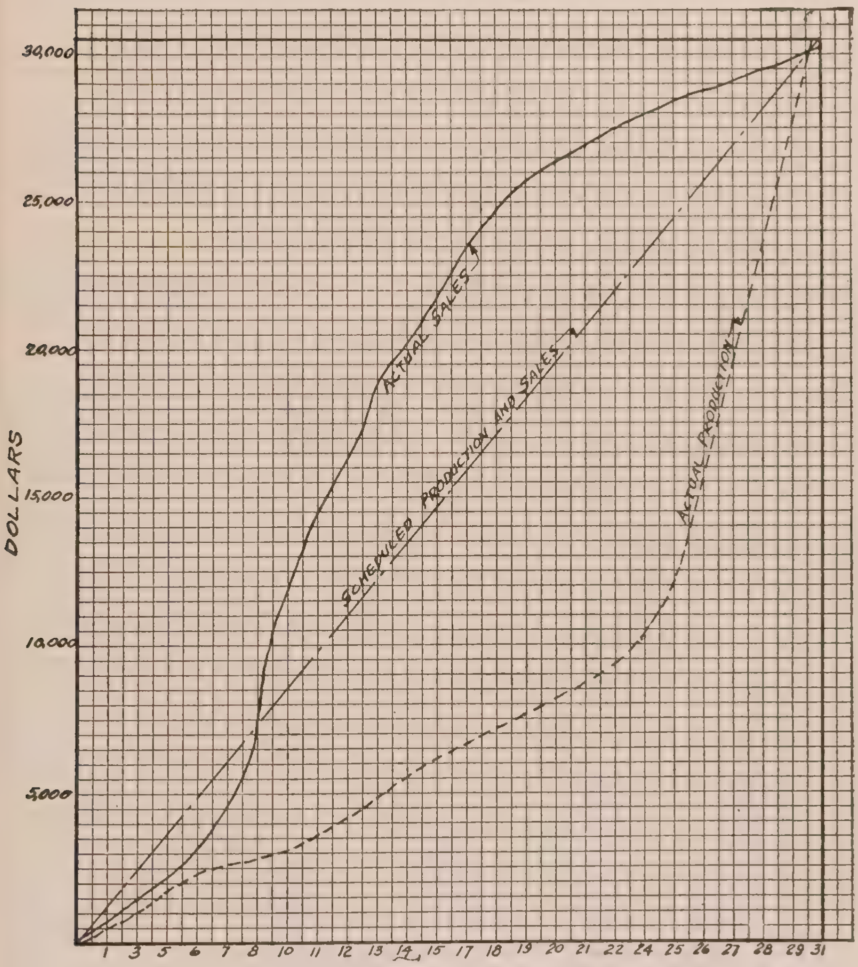
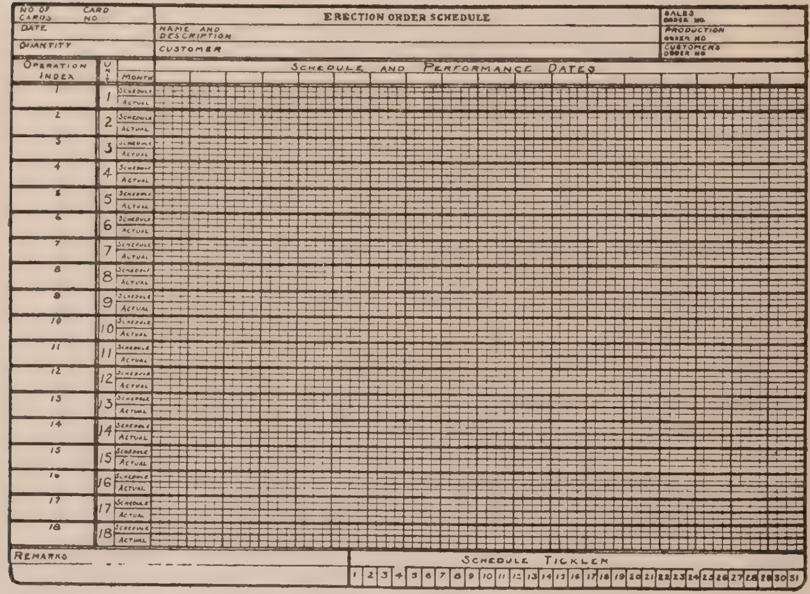


Fig. 80.—Master Schedule Chart.

The graphic representation of the production schedule is also of prime importance in many cases. One way in which it can be done is illustrated in Figure 81. A dotted line on the chart represents the schedule, the distance between the vertical spaces represents operations in the sequence listed at the left. The vertical background lines serve to divide each month into four periods of approximately a week in length, and when the schedule line is read against this background, the dates when the operations are supposed to be begun and finished are shown. A solid line indicates actual accomplishment, the vertical lines show the start and completion of the several operations. A comparison between the schedule line and accomplishment line reveals how closely the plans are being lived up to and what points in the course of production need particular attention. As the units in this illustration (marine engines) are very large, each one is scheduled separately. The same kind of chart might well be used in other factories by treating a batch or lot composed of many units as a basis for the schedule.



NO OF CARDS CARD NO
DATE
QUANTITY
ERECTION ORDER SCHEDULE
NAME AND DESCRIPTION
CUSTOMER
SALES ORDER NO
PRODUCTION ORDER NO
CUSTOMER'S ORDER NO
OPERATION INDEX
MONTH
SCHEDULE AND PERFORMANCE DATES

1	1	SCHEDULE ACTUAL	
2	2	SCHEDULE ACTUAL	
3	3	SCHEDULE ACTUAL	
4	4	SCHEDULE ACTUAL	
5	5	SCHEDULE ACTUAL	
6	6	SCHEDULE ACTUAL	
7	7	SCHEDULE ACTUAL	
8	8	SCHEDULE ACTUAL	
9	9	SCHEDULE ACTUAL	
10	10	SCHEDULE ACTUAL	
11	11	SCHEDULE ACTUAL	
12	12	SCHEDULE ACTUAL	
13	13	SCHEDULE ACTUAL	
14	14	SCHEDULE ACTUAL	
15	15	SCHEDULE ACTUAL	
16	16	SCHEDULE ACTUAL	
17	17	SCHEDULE ACTUAL	
18	18	SCHEDULE ACTUAL	

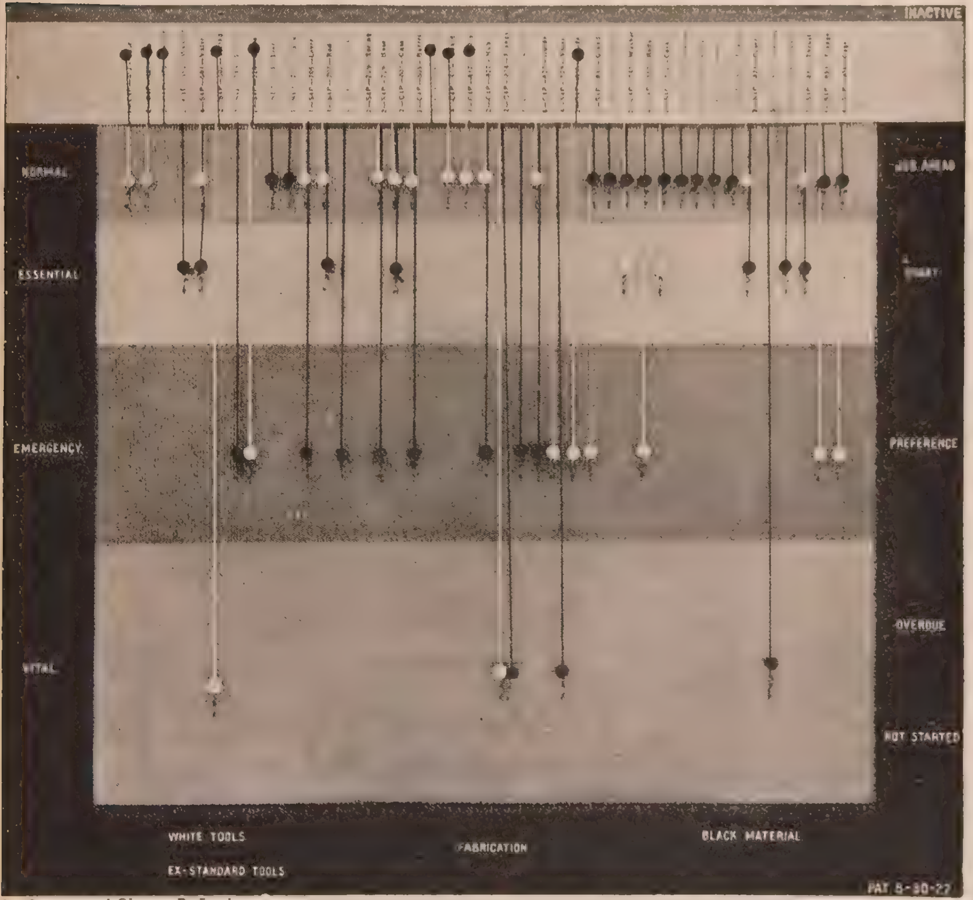
REMARKS
SCHEDULE TICKLER
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Fig. 81.—Erection Order Schedule.

A great many other methods of visualizing control records are available. It should also be noted that many of the reports previously mentioned, such as those for idle time of equipment and workers, can well be presented in the form of graphs. There are two types which are commonly used for this purpose, one on coördinate paper and the other on ratio paper.

The first of those is most satisfactory when it is desired to compare absolute figures for different facts or to compare absolute figures for different periods. The second is more useful when the percentage changes from period to period are being studied, for the percentage changes are shown in their true relation to each other.

"Tell-tale" board.—There is one other device for visualizing facts which has recently been developed and which has wide applicability in the control of production. It is shown in Figure 82. The device consists of an arrangement of weights



By Courtesy of Chester B. Lord.

Fig. 82.—Tell-Tale Board.

and cords so that hooks attached to the lines may be pulled down to any point on the screen. The screen is divided into several sections, each representing a certain condition of the factor to be controlled, and each cord represents a single unit of that factor. In the case of material, for example, if the hook for any item is in the top section of the board, it means that the supply of material is sufficient and does not need attention; if it is in the second section from the top, it shows that the quantity has fallen to the reorder point and that more is needed; if it is in the third section the supply has become dangerously low and needs constant following up; and if it is in the lower section it is a sign that all the material has been used up and that executive action is necessary. This board has been called the "tell-tale" because, if it is properly manipulated, it shows the condition of the factor recorded at any time and serves as a basis for appropriate action.

Conclusion.—The importance of visualizing records of all kinds is being more and more recognized at the present time. It renders them available for easy reference, it causes the exceptional condition or fact to strike the eye and so emphasizes its significance—and it is the exceptional item which usually demands executive action—it facilitates comparisons between plans, schedules, and results, between present, past and future dates, and in many other ways facilitates the control of the business as a whole as well as that of production in particular.

References for Additional Reading

Basset and Heywood, "Production Engineering and Costkeeping," Chapter XXVI.

Brinton, W. C., "Graphic Methods for Presenting Facts," passim.

Cartmell, M., "Stores and Material Control," Chapter XVIII.

Haskell, A. C., "How to Make and Use Graphic Charts," passim.

Karsten, K. G., "Charts and Graphs," passim.

Knoeppel, C. E., "Graphic Production Control," Chapters IV-VII, XI.

CHAPTER XXX

THE RELATION OF THE PLANNING AND COST DEPARTMENTS

Purposes of this chapter.—

1. To study the services which can be rendered the Cost Department by the Planning Department.
2. To outline the aid which the Cost Department can give the Planning Department.

The proper relation of the Planning and Cost Departments is relatively seldom realized in actual business. There are those, mostly factory executives, who believe that the cost records are really a part of the production control records, and hence should be kept in the Planning Department, in this way practically eliminating the Cost Department. They want to know certain facts in cost terms and they feel that most of the data needed for obtaining these costs comes from the production control records and that, for these reasons, cost accounts, and the activities involved in keeping them, belong under their supervision. Such individuals often fail to appreciate the other side of the problem, and, if their desires are satisfied, there is frequently no connection between the cost records and the general accounts, with lack of satisfactory accounting reports as a result.

On the other hand, there are those, often public accountants, who feel that the cost accounts exist solely for the purpose of aiding in the allocation of the values received when cash is disbursed. The fact that a large part of the information used by the Cost Department comes directly from the Planning Department and much of the data which it collates is largely, if not entirely, for the aid which it gives in the control of factory operations and is overlooked or ignored by them, with the result that the cost records tell only half truths and fail, to a considerable extent, to render the services of which they are capable. Such a person usually wants to incorporate the Cost Accounting Department in the General or Financial Accounting Department or make it subordinate to the latter.

The proper place of cost accounting in business control.—Both of these extreme positions are untenable for cost accounting is separate and distinct from both general accounting and the work of production control, although it is also closely related to both. The factory man is right in thinking that the cost records are an extension and amplification of production records and the accountant is right in feeling that the cost accounts are an integral part of the accounting system. Because of these facts the cost records need to be handled by a separate department closely coördinated with the other two. As the field covered by this book does not include accounting, the relationship [1] of the cost accounts to the general accounts cannot be discussed here.

The scope of industrial cost accounting.—The first question to be considered is the service which the Planning Department can render the Cost Department. Before this question can be answered, however, it is essential to have some conception of the nature and scope of industrial cost accounting. A brief and helpful, though not completely accurate, definition of industrial cost accounting is that it is a record in terms of dollars and cents of what goes on in the factory. Cost records are for the purpose of ascertaining the cost of the labor, material, and services, other than labor, which are involved in the production of merchandise. Some of these costs are direct, as in the case of most of the material which physically enters into the composition of the product and the labor which is used directly in modifying and changing the form and condition of the raw material entering into the completed merchandise. Other costs are indirect, like those involved in the supervision of the workers, the production of power, the design of tools, etc.

It is the task of the Cost Department to secure information concerning the costs of all these and record it in such a way that the figures so obtained will be useful in the control of the business. In general the costs may be divided into two main groups—(1) direct costs, or costs which may be charged directly and immediately against the finished product, or some part of it, and (2) indirect costs, or the costs of services which cannot be measured against any one unit or units of product, but which must be allocated in some indirect fashion. In the first group the two most important elements are the material out of which the merchandise is fabricated, and the labor involved in the actual transformation of this material. The second group is composed largely of the costs of managing and administering the factory, costs which are called expenses.

---

[1] For a discussion of this phase of industrial cost accounting see "A Text Book of Industrial Cost Accounting," by Paul M. Atkins, Chapter XXX, or "Industrial Cost Accounting for Executives," by Paul M. Atkins, Chapter XXVI; both books are published by McGraw-Hill Book Co., Inc., New York.

The relation of production control records to cost accounting.—From the discussion in preceding chapters, it is easy to see the part which the Planning Department has to play in this matter. As the material which enters into the product directly is one of the most important elements in the control of production, it is evident that it is natural for the Cost Department to look to the Planning Department for information concerning it. The Cost Department wishes to ascertain the value of the material used and this value can, of course, be calculated if the quantity issued and its value are known. In the control of material, the Planning Department is obliged to know, first, the quantity of material wanted for any particular order, batch, or job, and secondly the actual quantity issued. The material issues and credit slips provide for the recording of the data in regard to quantities which are, in turn, entered on the balance of stores or balance of worked material cards. When the Planning Department has completed its use of the issues and credit slip in the control of production, they are available for the use of the Cost Department to which they are immediately sent.

The pricing of material issues.—The problem of entering the prices on the issues and credit slips is the next one to be faced. The Planning Department does not have any direct need of a knowledge of material prices. It might seem quite logical, therefore, to allow the Cost Department to supply itself with this information, and in many cases this procedure is followed. In most instances, however, for the Cost Department itself to price the issues and credit slips satisfactorily means that it is necessary to keep a perpetual inventory of materials, thus duplicating the "on hand" section of the balance cards. This is usually unnecessary labor, and hence it is ordinarily best to allow the Planning Department to price the issues and credit slips.

One very important service which the Planning Department can render the Cost Department is the preparation of the information concerning direct material so that it can be used with a minimum of effort. It should also be noted that while material which does not enter directly into the fabrication of the product, and whose value, therefore, forms a part of the indirect costs, is not dispatched by the Planning Department, it is nevertheless recorded on balance cards or perpetual inventory cards which are maintained in the Planning Department, and hence they also are prepared for the use of the Cost Department by the Planning Department. In the jobbing type of industry where each lot of material is recorded on a separate issue or credit slip, the number of these issues and slips may easily run into the hundreds, and even the thousands, daily. An appreciation of this fact will aid in the realization of the importance of the service rendered by the Planning Department to the Cost Department and of the intimacy of their relations.

The preparation of time tickets.—In addition, the Planning Department also uses time tickets in the control of various operations in the shop, especially in the dispatching of the orders and workers. These tickets are stamped with the time when they are sent out and again when the job which they represent is completed. After being used for this purpose, they are available for the use of the Cost Department in calculating the labor charge. Of course, they must first be employed for making up the payroll, but very frequently this function is considered a part of the work of the Cost Department. The time is recorded on the tickets in the Planning Department, in making up the payroll, the worker's rate is entered and the value of his labor recorded, so that when these tickets reach the main section of the Cost Department they are ready to be used in compiling the costs.

If a bonus system of wage payment is in use it is essential that certain additional information be provided, over and above that on the time tickets, before the pay records can be calculated and the labor costs ascertained. In most cases, a bonus or premium is paid only on work which is satisfactory.

Spoiled parts are not considered and, in some cases, not even charged against the worker. Hence it is essential to know how much good work an employee turned out as well as the length of time which was taken to complete the task. The Planning Department furnishes this information by means of the inspection tickets which it uses for the control of the inspection of the goods as they pass through the various processes.

Other records furnished by the planning department.—Through the material issues and credit slips and the time and inspection tickets the Planning Department provides the Cost Department with a very large majority of the number of items which it has to handle in the calculation of the costs of product and of the operation of the factory. In some cases, it also furnishes other data in the form of the set-up tickets from which alone, or in connection with certain time tickets, the costs of the machine set up can be calculated, information which often is needed in deciding upon the size of the economical order from the point of view of the factory. The Planning Department can also supply special time tickets on which are recorded the length of time that the machines are idle and the reasons, and other tickets showing the idle time of the workers and the causes thereof. From these and other special records which may be maintained permanently or intermittently by the Planning Department, the Cost Department can obtain much data from which a report of considerable value in the control of the business may be obtained. When all these various vouchers which are sent to the Cost Department from the Planning Department are considered, it is easy to see how the cost records may be thought of as an extension of the production control system.

The auditing of the vouchers prepared by the Planning Department.—The service which the Cost Department can render the Planning Department begins with these very same vouchers as soon as they are received by the former department. This first service may be described briefly as an "auditing" of the vouchers to catch any mistakes which may have been made. A great deal of the work of the Planning Department is done under pressure, and it is not surprising that mistakes are made when the mass of vouchers used and handled is considered. It frequently happens, also, that errors occur in the Stores Department or out in the shop itself which are not seen and corrected.

The Cost Department, on the other hand, can work in a relatively leisurely fashion. If it gets behind in its work one day it has a chance to get caught up the next, and, unless some serious trouble is encountered, the worst that could happen would be to delay for a few days the closing of the ledger and the preparation of certain reports. The Planning Department, however, must keep up to date all the time, for if it does not, some or all of the direct manufacturing departments are likely to be compelled to stop work for lack of proper control by the Planning Department. An important service which the Cost Department can render is to watch for any errors which occur and return the vouchers affected to the Planning Department for correction. As it is not working under such pressure as the latter department, it can afford to take the time to scrutinize the various slips with this idea in mind.

From one point of view this auditing of the production control vouchers used in the preparation of the cost records is simply a matter of self-protection, for, if errors are allowed to slip by uncorrected, the cost records in turn will be inaccurate, and hence the work performed in keeping them will be largely wasted. If the Cost Department does its work as promptly as it normally should, any mistakes which have been made on the vouchers can be returned and corrected soon enough, in many cases, to prevent the mistake from doing any serious damage, such as upsetting schedules, causing a shortage of materials, etc. It is in this way that the Planning Department is very substantially aided in performing its task by this auditing.

Auditing methods.—In most cases, it is not at all necessary to make a special operation out of the verification of the accuracy of the vouchers received. In fact, it would be practically impossible to check all the entries, for the necessary information would not be available and it would require the time of so many clerks in the Cost Department that its cost would be prohibitive. The auditing should be done continuously by every one in the Cost Department who handles the vouchers. If each clerk will hold up any voucher on which any item seems to him to be questionable, especially any item which he is using in his task, it will be found that most of the errors will be quickly caught.

The possibility of doing all this depends, in the first place, on the willingness of the cost clerks to do this work. If they are unwilling and refuse to do it, there is practically no way of compelling them. Their coöperation can be secured only by building up their morale and by giving them adequate support and supervision. If they know that the company executives are really interested in having this checking done and that any apparent errors which they find will receive careful attention, it is not difficult to build up the needed morale if the clerks are of the proper calibre.

In addition to a willingness to coöperate, it is necessary for the clerks to know enough about the data with which they are working to be able to detect errors when they come to their hands. To a large extent this knowledge can be developed only by systematic training. It is highly desirable, whenever possible, for the cost clerks to work for a while in the Planning Department and learn something about the nature of the work there. It is also very helpful if they can work for a time in the shops and storeroom in addition. Such experience gives them a background for any further instruction and a perspective for that work which should make any further preparation for this part of their task easy.

Tact is necessary for this auditing.—The actual return of the vouchers to the Planning Department for correction demands a certain amount of tactfulness. No person or department likes to have its mistakes—real or apparent—thrown back at it. It is necessary, therefore, for the individual who has the task of taking up the mistakes to act courteously and considerately, and it is also essential for the members of the Planning Department to appreciate fully that what is being done is largely for their benefit. One of the principal difficulties in the part in this connection has been the failure of the personnel of both departments to understand what is involved in this checking up process. Another cause of the failure to maintain harmonious relations has been due to a lack of any definite procedure for the adjustment of the apparent discrepancies. Both of these difficulties can easily be removed by a competent executive.

Cost reports to aid production control.—The auditing of the vouchers which are received from the Planning Department is only a beginning of the service which the Cost Department can render the former. Another form of service which is more apparent, and of vital importance, is the information which may be obtained from the cost records which may aid in the control of production. The Planning Department deals almost exclusively with physical units, and necessarily so, in its control of production. There is a great deal that it needs to know which is best recorded in dollars and cents in order to bring out the real significance. The reports on idle time offer an example of this kind of thing. These reports would show the number of hours which each production center was idle and the cause thereof. Such information is important and valuable, but it is not the whole story. It looks just as bad on a report of this kind to see that a bench, equipped perhaps with a vise and bench plate, is idle for ten hours as it does to note that a 40 inch engine lathe or a 6 inch automatic has been idle the same length of time. On the other hand, when it is shown that the loss in the first case was only about $1.00 and in the other instances $40.00 to $60.00, the relative importance of the idleness assumes a very different significance.

The cost of idleness.—It is from the cost records that a report showing the relative cost of idleness of the various production centers can be obtained and its value to the factory executives is evident. It is not a matter of much importance if the bench stays unused for a few hours. The loss is inconsequential, but it is of vital consequence to see to it that the machines referred to are kept busy. The relative importance of close scheduling and dispatching is brought out by a report of this kind.

The type of report should also be made in connection with the idle labor, though, in this case, the significance is not brought out so vividly in the cost report over the production as in the case of equipment, since wage rates do not have the same extensive spread as do burden rates. Nevertheless, it is desirable for the factory executives to learn just how much their idle men are costing them. In some cases, of course, it is more profitable to accept the loss than to expend large sums in trying to eliminate the causes. It is well, however, to have a decision of this kind based on definitely ascertained facts and not on intuition.

Comparison of actual costs with standard cost.—It is of considerable importance to the factory executives to know how much it is costing to operate each department in the plant. It is of even more significance to them if they are in a position to compare the actual costs of operation, commonly called expenses, with the scheduled or budgeted expenses. Such data gives them one basis for the efficiency and effectiveness of the control exercised by the several department heads. It should be realized that this is only one basis for measurement, and that care must be employed in using it, as changed conditions from those envisaged when the forecast was made may cause the actual results to be quite different from those expected and all through no fault of the department head.

Product and operation costs.—The Cost Department should also be in a position to supply information about the cost of the product or any unit entering into its composition which is made in the factory. In some cases, the desired data is most useful in the form of unit costs, and in other instances as operation or process costs. In some few places both kinds of costs are needed to supply adequate information for the control of production. If the cost records have been properly organized there should be no serious trouble in most cases in supplying any figures desired. Occasionally the Planning Department or some factory executive calls for costs which are seldom wanted and which the cost records are not planned to supply. Often such costs are difficult and expensive to obtain, but if their value in the control of the factory is sufficient to warrant the necessary expenditure to get them, it should be possible to arrange their calculation.

As in the case of expenses, it is often extremely valuable to the factory executives to have a basis of comparison for the actual costs of production. This basis is found in the form of standard costs or cost standards which are worked out from the manufacturing standards and which show what the operation or product should cost under normal conditions. These cost standards should be prepared by the Cost Department whenever they are wanted and should be modified from time to time as changing conditions modify the normal costs.

It should be evident from the foregoing paragraphs that the interests of the Planning and Cost Departments are closely united. Each is in a position materially to assist or hinder the other. A good organization under the management of a capable executive will see to it that these two activities function together without friction to the lasting benefit of the company. The illustrations which have been suggested in the preceding paragraphs present only a few of the many interrelations which may exist, but they serve to outline the scope of field involved and give some idea of the significance of the problem in the effective administration of a manufacturing concern.

References for Additional Reading

Atkins, P. M., "A Textbook of Industrial Cost Accounting," Chapters VI, XXXII.

Eggleston and Robinson, "Business Costs," Chapters IV, VI.

Lansburgh, R. H., "Industrial Management," Chapter XLIII.

INDEX

A

Accidents, reduction of, by maintenance, 134
Accounting department, 303
  financial, 27, 29
Administration, 2
  factory, 9
    meaning of, 1
  functions, 22, 29
Advertising department, 29
Allowances, 189
  fatigue, setting of, 199
Alternating current, 81
Analysis, 7
  of cost factors, 55
  of equipment, 53
  of functions, 23
  of manufacturing processes, 105
  of materials, 17
Artificial lighting, power consumption of, 66
Ashes, 74
Assembling operation order, 252
Assembly department, 108
Assembly operation card, 147
Automatic lathe, 52, 59
Automatic sprinkler, 124
Automatic stokers, 73
Auxiliary equipment, power consumption of, 66
Auxiliary manufacturing functions, 30

B

Babson reports, 304
Balance of stores card, 287
Basic functions, 1
Basis for selection of workers, 151
Batch, unit for scheduling and dispatching, 329
Belting, 80
  effect on time studies of, 178
Bibliography, 11, 21, 33, 47, 62, 82, 103, 115, 130, 142, 149, 157, 165, 174, 190, 200, 218, 229, 260, 269, 280, 294, 305, 316, 329, 339, 349, 356, 366, 376
Bidding for material, 300
Binder, 49
Bins, double, 312
  hopper, 312
Bin tag, 314
Blue print and photographic department, 25
Boiler furnace, 73
Boilers, 70
Bonus record ticket, 256
British thermal units (B. T. U.'s), 75
Brookmire reports, 304
Budgeting, 262
Building construction, 5, 19, 92
  effect of equipment on, 117
  effect of product on, 117
  frame, 122
  height of, 119
  limitation of location on, 118
  mill or slow type, 122
  reinforced concrete, 126
  roofs, 130
  steel frame type, 125
  types of, 121
Building foundation, 120
Building walls, 127
Building with glass walls and monitor roof, 128
Business cycle, effect on purchasing, 297
Business problems, similar, 2
Buying department, 30

C

Capital investment, effect of upkeep on, 133
Cashier, 27
Castings order, 245
Central power stations, 68
Chair, designed to relieve fatigue, 197
Chami-grate stokers, 73
Charts, floor plan, 112
  line and staff type of organization, 38
  line type of organization, 36

Charts (*Cont.*):
  maintenance organization, 141
  master schedule chart, 364
  material purchases control, 296
  materials control, 293
  production control, 279
  route, 173
  showing other relations than authority and responsibility, 45
  Taylor type of organization, 41
  typical organization, 44
Chemical laboratory, 27, 28
Chemistry, 6, 62
Chimneys, 75
Classification, 219
  accounting, 224
  assets, 225
  basis of, 223
  current assets, 225
  equipment, 227
  materials, 226
  of functions, 23
  of tools, 330
  practical, 224
  property, 225
  relation to symbolization of, 220
  significance, of in factory administration, 220
  standards, 228
  supplies, 227
Clinker, 75
Clothing, effect on fatigue of, 198
Coal, 75
  storage of, 75
Color, 144
Combustion, 74
Commercial, cost accounting department, 29, 30, 31
  standards, 15
Compressed air, 82
Compression, 144
Condenser, 77
Construction of factory building, 116
Containers, shipping, 352
Continuous process type of industry, plant layout for, 107
Control, 2
Conveyor, motor-driven horizontal portable, 88
Corrugated glass, 129
Cost accounting department, commercial, 29, 30, 31
  industrial, 29, 31
    place of, in business control, 368
    scope of, 368
Cost department, 28, 59, 232
  relation to planning department, 367
Cost factors, analysis of, 55
Cost reports, an aid to production control, 374
Costs, actual, comparison with standard cost, 375
  of idle equipment, 49
  operation
  product, 375
Counting scale, 313
Courses of instruction at night school or factory, 208
Crane, electromagnetic, 100
  mono-rail, 92
  overhead traveling, 92, 97
  used as elevator, overhead, 99
Credit and collection department, 28
Credit slip, 314
Customers' Service department, 30

D

Damaged stores, treatment of, 347
Departmentalization, 34
Departments, functional units, 25
Depreciation, effect of upkeep on, 133
Design, and development of product functions, 25
  functions, relation to other functions, 26
  of factory forms, control of, 232
  of printed forms, 230
  of product, 12, 20
  of tools, 19, 331
Designing department, 272, 341
Dewey decimal system of symbolization, 221
Diesel engine, 79
Direct current, 81
Dispatch board, 324, 325
  maintenance control, 140
  significance of, 326
Dispatch clerk, 320
  location of, 323
  relation of to factory foremen, 322
Dispatching, 317
  coördination in respect to time and place, 318
  definition of, 271
  in a continuous process type of factory, 318
  in the jobbing type of factory, 319
  of equipment, 319
  of material, 320

Dispatch of orders, control of, 324
  follow-up of, 321
Distribution functions, 22, 29
Drafting department, 25
Drills, 336

E

Earned burden, 347
Ease of manufacture, 18
Economizer, 70
Elasticity, 144
Electric current, 81
  use of for internal transportation, 91
Electric generators, 81
Electric power transmission, 81
Electric storage battery tractor and trailers, 92
Electric storage battery truck, 89
  handling heavy tools, 91
Electromagnetic crane, 100
Elevating platform truck, hand-power, 85
Elimination of parts, savings from, 13
Employee specifications, 228
  benefits of to workers, 156
  elements of, 152
  intellectual qualities, 152
  moral qualities, 153
  physical qualities, 152
  samples of, 154-5
  use of, for control of production, 156
Employee standards, 162
Employment department, 157
Engine accessories, 76
Engine, Diesel, 79
  gas, 78
  internal combustion, 78
  lathe, 57
  multiple expansion, 77
  steam, 76
Engineering department, 20, 21, 25, 31, 212, 272, 284, 297, 341
Engineering mechanics, 62
Equipment, analysis of, 53
  classification of, 227
  dispatching of, 319
  effect of on building construction, 117
  factor in scheduling production, 276
  idle, importance of, 49
  integration of, 52
  internal transportation, 4, 19, 83
Equipment (*Cont.*):
  records, 361
  requirements, analysis of, 48
  selection of, 3, 18, 48
    effect of labor supply on, 52
    effect of process on, 51
    effect of product on, 50
    effect of rate of production on, 52
  standards, 161
    effect on time studies of, 178
  stockroom, 351
  storeroom, 310
  tool storage, 336
Erection order schedule, 363
Esprit de corps, 269
Exception rule, 359
Executive, department, 29, 31
  factory, task of, 2
  records depending on type of, 358
Expenses, disbursements for, 267
Experimental department, 21, 26
Export shipments, 353

F

Factors controlling plant layout, 104
Factory administration, 9
  meaning of, 1
Factory executive, task of, 2
Fan bracket, 18
Fatigue, allowances, 198
    setting of, 199
  classification of causes of, 194
  effect of clothing on, 198
  elements of work affecting, 194
  how experienced, 193
  interest of worker and employer in, 192
  measurement of, 195
  nature of, 191
  reduction of, 196
    control of worker over, 197
  reduction of output by, 192
  reduction of quality by, 193
  relation of, to standards, 163
  tests, 195
Fayol, Henri, 9
Filing department, 26
Financial accounting department, 27, 29
Financial department, 27
Financial functions, 27
Financial schedule, 266
Finished product, 2, 12
  stocking of, 350

Finished stock and shipping department, 32, 108, 354
Fire doors, 120
Fire hazards, 93, 119
Fire tube boilers, 70
Floor plan, 112
Fluids, movement of, 19
Forecasting the future, 261
Foremen, relation of to dispatch clerks, 322
Foundation, building, 120
Frame construction, 122
Fuel, choice of, 75
Functionalization, 3
Functions, 22
  administration, 22
  analysis of, 23
  auxiliary manufacturing, 30
  basic, 1
  classification of, 23
  design and development of product, 25
  distribution, 22, 29
  financial, 27
  general administration, 29
  manufacturing, 22
  marketing, 22, 29
Furnaces, boiler, 73

G

Gang motor, 81
Gas engine, 78
Gears, 81
General administration functions, 29
General office department, 29
Gilbreth, F. B., 197
  Mr. & Mrs. F. B., 182
Graphic methods for recording plant layouts, 110
Gravity chute, 95
Grinding of tools, 357
Group issue, 258, 291, 320

H

Hammar, 18
Hammond, John Hays, 10
Hand-power elevating platform truck, 85
Hand vs. power transportation equipment, 98
Harvard economic reports, 304
Hathaway, H. K., 222
Heating, power consumption of, 67
Heat, light, and power department, 32
Height of building, 119
Horizontal movement of material, 96
Hydro-electric power, 69

I

Ideal factory layout, value of, 104
Idle equipment, importance of, 49
  reduced by maintenance, 134
Idle time reports, 359
Impermeability, 144
Incentive methods of wage payment, essentials of, 217
Incentives, relation of to permanency of standards, 216
Income, sources of, 267
Industrial cost accounting department, 29, 31
Industrial cost accounting, place of in business control, 368
  scope of, 368
Industrial relations departments, 28
Industry, nature of, affecting internal transportation, 87
Inspection, basis of quality, 341
  comparison of actual with standards, 342
  extent and methods of, 343
  final, dispatching of, 321
  first, control of, 327
  of goods-in-process, 344
  of incoming shipments, 308
  quality, 340
  quantity, 340, 344
  significance of, 341
  ticket, 257
Inspection department, 32, 308
  place in organization, 345
Inspectors, 345
Instruction cards, 202-4, 228
  preparation of, 205
Instruction of employees, by department executives, 210
  by foremen and subforemen, 207
  continuous, 207
  general, 208
Integration of equipment, 52
Intermittent industry, effect on selection of equipment, 57
Internal combustion engine, 78
Internal transportation department, 32
Internal transportation equipment, 4, 19, 83
  power, consumption of, 66
Inventory, 314

Invoice, passing of, 302
Isometric sketch of plant layout, 114

J

Job analysis, 151
Jobbing type of industry, plant layout for, 109

K

Kent's acuteness of hearing and sight tests, 195
Key, National Cash Register, 13
Kinematics, 62

L

Laboratory, chemical, 21, 26
  physical, 21, 26
Labor, schedule, 265
  selection of, 19
Lathe, automatic, 57-59
  dogs, 336
  engine, 57
  tools, 336
  turret, 57-59
Layout of stockroom, 351
  of storeroom, 311
  of tool crib, 337
Lectures for employees, 208
Lignite, 75
Limitation of location on building construction, 118
Line and staff type of organization, 36, 38
Line type of organization, 36
  disadvantages of, 37
Luxury goods, 16

M

Machine, design, 62
  operation order, 247
  set-up ticket, 253
Machinery, special, 56
  standard, 56
    and special, relationship between, 59
Maintenance, 132
  classification of, 135
  control, dispatch board, 140
  department, 32
  of tools, 336
  organization chart, 141
  planning of, 136
Maintenance (*Cont.*):
  plant, 5
  reasons for importance of, 132
  regular but infrequent, control of, 137
  schedule, 138
  scheduling of, 136
  time ticket, 139
Management, 2
  art of, 8
  science of, 8
Manager, qualities necessary to, 9
Manual organization, 43
Manufacture, case of, 18
Manufacturing, functions, 22
    auxiliary, 30
  order, 283
  processes, analysis of, 105
  standards, 20
    basis of, 160
    control of, 273, 274
    department, 20, 31, 38, 39, 145, 272, 280, 331, 335, 341
    effect of up-keep on, 133
    planning and scheduling, 276
    tool design a part of, 339
Marketing functions, 22, 29
Market knowledge, an essential to buying, 297
Martin and Rich's spring balance test, 195
Master schedule, 7, 261, 262
  chart, 365
  preparation, 268
  relation to production scheduling, 276
Material, 5
  analysis of, 17
  bidding for, 300
  characteristics of, 142
  classification, 226
    from control standpoint, 281
  compressibility of, 144
  conductivity of, 144
  control, factors in, 282
  dispatching of, 320
  durability of, 144
  elasticity of, 144
  handling equipment, 99-103
  issue forms, 314
  issue of, 312
  issues, 320
  kinds to be inspected, 343
  list, 284
  movement of, 84

Material (*Cont.*):
  ordering of, 286
  pricing of, 369
  purchase of, 30
  rejected, disposal of, 346
  schedule, 265
  scheduling of, 278, 282
  selection of, 144
  specification card for, 147
  specification of, 144
    economic aspects of, 145
  specifications record of, 146
  standardization, 146
  standards, 160
    effect on time studies of, 177
  strength of, 144
  symbolization of, 148
  visualized specifications of, 361
Maximum and minimum quantities, 286
Measurement of goods for shipment, 351
Mechanics of materials, 6
Merchandise, measurement of for shipment, 551
  received in stores slip, 241
Metallurgy, 6, 62
Military type of organization, 36
Milling cutters, 336
Milling machine, 56
Mill type building construction, 122
Mnemonic symbols, 23
  advantages of, 221
Models, 21
Monitor roof, 128
Mono-rail cranes, 92, 93
Moral qualities, 9
Mossos ergograph, 195
Motion pictures, use for making time and motion studies, 182
Motion studies (see time studies)
Motor driven truck equipped with crane, 86
Motors, 81
Movement of material, direction of, 95
  dispatching of, 321
Move order, 244, 246, 250, 255

N

National Cash Register key, 13

O

Operation, analysis into suboperations, 183
Operation (*Cont.*):
  and route record, 171
  costs, 375
  order, 249
  standards, 202, 275, 362
    allowances, 189
    setting of, 162, 187
Order of work, control of, 326
Orders, control of, 278
  dispatched, follow-up of, 321
Organization, 2, 3, 22
  chart, 43, 360
    maintenance, 141
  line and staff type, 36
  line or military type of, 36
  manual, 43
  of finished stock and shipping department, 354
  on basis of functions, 34
  place of committees in, 41
  place of individuals in, 45
  pseudo, 35
  relations other than those of authority and responsibility, 42
  Taylor type, 36
  types of, 36
Overfed stokers, 73
Overhead travelling cranes, 92, 97
  used as elevator, 99

P

Packing goods for shipment, 352
Parts, savings from elimination of, 13
  standardization of, 15
Paymaster, 27
Petten-Roper's carbon dioxide test, 195
Physical laboratory, 4, 26
Physics, 6, 62
Piston, 76
Planer, 54
Planer spikes, 336
Planer tools, 336
Planning, definition of, 270
Planning department, 15, 31, 32, 38, 39, 40, 157, 212, 213, 232, 270, 271, 322, 339, 357
  function, 210
  relation to cost department, 367
  work audited by cost department, 371
Plant layout, 5, 104, 361
  charts of, 110
  factors controlling, 104
  future expansion, 110

Plant layout (*Cont.*):
  graphic methods for recording, 110
  in jobbing type of industry, 109
  in the continuous process type of industry, 107
  isometric sketch of, 114
  skeleton of building and templates, 113
Plant maintenance 5, 132
Plant register, 59-61
Polishing operation order, 251
Portable elevator, electric, 97
Power consumption, fluctuation in, 65
  measurement of, 64
  unavoidable losses, 68
Power department, heat, light, and power, 32
Power problem, nature of, 63
Power production, 4, 63
  by central power station, 68
  hydro-electric, 69
  steam, 69
Power requirements, 64
Power transmission, 4, 63, 79
  electric, 81
Power transportation equipment, hand vs., 98
Principles, 8
Printed forms, arrangement of spaces on, 231, 234
  defects in design of, 231
  importance of, 230
  preparation of by duplicating devices, 246
  reasons for utility of, 231
  ruling of, 259
  size and shape of, 233
  typewriter spacing between lines, 258
  typography of, 259
Product, costs, 375
  design of, 12, 20
  effect of on building construction, 117
Production, centers, 64
  control of, 7
  control of current, 362
  control records, 359
    relation of cost accounting, 369
  dependence of on other functions, 261
  engineering department, and, 211
  manager, specifications of, 155
Productive capacity of a factory, 263, 264
Pseudo organization, 35
Punch presses, power consumption of, 66
Purchase control forms, 289, 303
Purchase of material, 30
Purchase order, 290, 301
  follow-up of, 302
  preparation, 303
Purchase requisition, 288, 303
Purchase schedule, 298
Purchasing department, 30, 215, 271, 298, 307
Purchasing procedure, 299
Purchases, control of in transit, 302

Q

Quantity of production, effect on routing, 168

R

Receiving department, 32, 108, 303, 304, 309, 343
  location of, 306
Receiving materials, 306
Receiving slip, 291, 304, 307, 314
  disposition of, 309
Records, basis for selection of, 357
  for control of production, 359
Refrigeration, power consumption for, 67
Reinforced concrete construction, 126
Reinspection of unsatisfactory goods, 347
Rejected materials, disposition of, 346
Relationship of planning, scheduling, and dispatching, 271
Reports, availability of, 360
Requisites for satisfactory purchasing, 295
Requisition, purchase, 288, 303
Rest periods, 198
  setting of, 199
Return of rejected materials slip, 292
Roe, Joseph W., 10
Roller conveyor, 101
Roofs, 130
Rope drive, 79
Route chart, 173
Route record, 171
Routing, 162
  alternative equipment, 169
  an analysis of direct manufacturing functions, 166
  a technical and economic problem, 167

Routing (*Cont.*):
  effect of quantity of production, 168
  factors of, 168
  orders through the shop, 273
  record of, 170
Rush operation order, 248
Ryan's vascular skin reaction test, 195

S

Sales department, 29, 212
Sales schedule, 264
Salvage, department, 349
  of spoiled worked material, 347
  operations, control of, 348
  work, organization of, 348
Savings, from elimination of parts, 13
  from standardization, 16
Saw tooth roof, 130
Scale, counting, 313
Schedule card, 327
Scheduling, definition of, 27
Scientific management, principles of, 214
Scientific method, 7
Scrap, 347
Selection of equipment, 18, 48
  effect of labor supply on, 52
  effect of process on, 51
  effect of product on, 50
  effect of rate of production on, 52
Selection of labor, 19
Selection of workers, 150
Service department, customer's, 30
Shafts, 80
Shaper, 55
Shaper tools, 336
Shipments, control of, 355
Shipping containers, 352
Shipping department, 351
  finished stock and, 32
Shoes, effect on fatigue of, 198
Shop committees, 28
Shortage reports, 359
Slow-moving type building construction, 122
Small scale production, effect on selection of equipment, 57
Special machinery, 56
  relationship to special, 59
Specification, accurate, needed for purchasing, 295
Specification card for materials, 147
Specifications, change of. 300
  economic aspects of, 145
  planning and scheduling of, 272
  record of, 146
Specific heat, 144
Sprinklers, automatic, 124
Square D Tales, 214
Staff type of organization, line and, 36, 38
Standard cost, comparison with actual, 375
Standardization, of materials, 146
  of parts, 15
  of savings from, 16
Standard machinery, 56
  relation to special, 59
Standard parts analysis, 171-2
Standard practice instructions, 202, 228, 319
  preparation of, 205
Standards, affected by time and motion study, 175
  classification of, 228
  commercial, 15
  development of, 159
  equipment, 6, 161
    effect on time studies of, 178
  for employees, 162
  making permanent of, 164, 201
  manufacturing (see manufacturing standards)
  material, 160, 300
    effect on time studies of, 177
  means of transferring thought, skill, and intelligence, 158
  operation (see operation standards)
  product, 6
  workers, 6
Standard sizes of printed forms, 233
Standard time, calculation of, 189
Steam boilers, 70
Steam engines, 76
  compared, 78
  economy of, 77
  reciprocating, 76
Steam power, 69
Steam turbine, 77
Steam, used for heating, 67
Steel frame type construction, 125
Stocking finished product, 350
Stock-room, 351
  layout and equipment of, 351
Stokers, 73
Stop watch, use for making time and motion studies, 182
Storage of coal, 75
Storekeeper, specifications of, 155

Storeroom, equipment, 310
  layout of, 311
  location of, 309
Stores card, balance of, 287
Stores credit slip, 237, 314
Stores, damaged, treatment of, 347
  definition of, 281
  department, 32, 108, 291, 319
  inspection report, 315
  issue, 236, 242-3, 291, 320
Strength of materials, 62, 144
Suboperation, importance of correct determination of, 183
Superheaters, 72
Supplies, classification of, 227
Symbolization, 219
  methods of, 221
  of materials, 148
  relation to classification, 220
  significance of in factory administration, 220

T

Taylor, F. W., 8, 40, 80, 179, 182, 222
Taylor type of organization, 36, 38
Tell-tale board, 365
Templates, 133
Tensile strength, 144
Textile factories, 20
Tiering lifting truck, 90
Time studies, 175
  basis for employee specifications, 151
  concealed, 180
  constructive, 188
  function of, 163
  location of, 181
  methods of making, 182
  position of observer, 187
  preliminary to, 177
  recording times of, 187
  relation of worker to, 176
Time study engineer, qualifications of, 163, 180
Time study sheet, 184-6.
Time study watch, 186
Time ticket, 235, 254, 320
  maintenance, 139
  preparation of, 370
Tolerances, 145
Tool cribs, 336
  attendant, duties, 337
  classification of, 330
  layout of, 337
Tool designing department, 274, 317, 331, 335
Tool issue, control of, 338
  double check system, 339
  single check system, 338
Tool manufacturing department, 32, 274, 318, 331
Tool order, 333
Tool production, relation of to merchandise production, 332
Tool standards, effect on time studies of, 178
Tools, design of, 19, 331
    control of, 333
  and production, planning, and scheduling, 274
  grinding, 337
  maintenance of, 336
  storage and issue of, 335
Tool storage equipment, 336
Tractor and trailers, electric storage battery, 92
Traffic department, 29
Transportation department, internal, 32
Transportation equipment, internal, 83
Treasurer, 27
Truck, electric storage battery, 89
    handling heavy tools, 91
  hand-power elevating platform, 85
  lifting tiering, 90
  motor driven, equipped with crane, 86
Turbine, steam, 77
Turret lathe, 57-59
  hand, specifications of, 9, 154
Typical organization chart, 44

U

Underfeed stokers, 74
Unearned burden, 50
Universal milling machine, 56

V

Vernon's complex test, 195
Vertical movement of material, 95
Von Heinholtz's myograph, 195
Vortands' carbon dioxide test, 195

W

Walls of building, 127
Watchman and fire protection department, 32
Water power, 69

Water purification, 70
Water tube boilers, 70, 71
Welfare department, 28
White, Maunsel, 179
Wire glass, 129
Worked material, bin tag, 315
  credit slip, 239, 314
  definition of, 281
  in slip, 314
  issue, 238, 291, 320
  received in stores slip, 240
  salvage of spoiled, 347
Work, elements of, affecting fatigue, 194
Workers, 6
  basis for selection, 151
  control of, 278
    over fatigue reduction, 197
  kind of, needed for time studies, 179
  relation to time and motion study, 176
  selection of, 150
Work order, 138

THE LIBRARY
UNIVERSITY COLLEGE
GALWAY